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Going down through the ice of Toronto Bay to saw off a propeller blade.

THE DIVER IN WINTER.—[See page 158.]

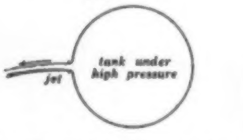
Some Phenomena of Fluid Motion*

The Curved Flight of a Baseball

By W. S. Franklin, Sc.D., Professor of Physics, Lehigh University, Member of the Institute

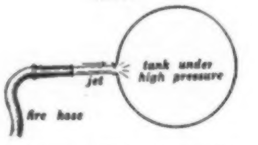
The steady curvature of path of a rapidly spinning baseball in flight is explained on the basis of a principle which was first enunciated by Daniel Bernoulli several hundred years ago. Bernoulli's principle is illustrated in Figs. 1 and 2. In a stream of water or air the pressure is high where the velocity is low, and the pressure is low where the velocity is high. In the following discussion it is not desired to take account of gravity, and therefore Bernoulli's principle is stated for the case of a horizontal stream. Also the effects of friction are ignored; as here stated, therefore, Bernoulli's principle applies only to approximately frictionless fluids, and indeed the principle applies only to cases of steady flow.[1]

FIG. 1.



In the tank the water has high pressure and low velocity; in the jet the water has low pressure and high velocity.

FIG. 2.



A fancy method for pumping water into a steam boiler. In the jet the water has high velocity and low pressure.

Diagram showing Bernoulli's principle of pressure and velocity.

The Venturi Tube.—Air is blown through a tube CD (Fig. 3). The velocity of the air is larger at a than at b, therefore, according to Bernoulli's principle, the pressure of the air is larger at b than at a. This excess of pressure at b is shown by the difference in level of the liquid in the two tubes T and T^1. If one blows hard enough through CD the liquid in T will be drawn up into the throat at a, where it will be broken up into spray.

The Disk Paradox.—A brass disk DD (Fig. 4) is soldered to the end of a tube T, and a light metal disk dd is held against DD by blowing strongly through T. The region between the two disks is a region of high velocity, and as the stream comes out at the edge of the disks its velocity falls and its pressure rises, according to Bernoulli's principle. Therefore the pressure of the air in the region between the two disks is less than the pressure of the outside air, and consequently the outside air pressure holds the two disks together.

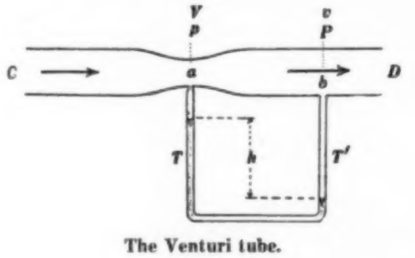
A complete hydraulic analogue of Fig. 4 is shown in Fig 5. A thin metal disk dd is kept from moving sidewise by a pin p which projects through a small hole in the disk, and the disk is held up by the jet of water. The jet spreads out over the disk as a thin layer of rapidly moving water, and when this flowing water reaches the edge of the disk it loses its velocity and raises itself to the higher level of the still water in the basin.

The Ball and Air Jet.—A small ball floats steadily in an air or steam jet, as shown in Fig. 6. The impact of the jet against the ball holds the ball up, and when the ball starts to fall out of the jet, as shown in Fig. 6, it is pushed back into the jet because the pressure of the surrounding still air is greater than the pressure of the rapidly moving air in the jet (Bernoulli's principle).

An ordinary file handle may be supported by an air jet, as shown in Fig. 7.

Attraction of Two Ships Steaming Along Side by Side.—As a ship steams along through a body of still water, the water at a given point moves as the ship approaches, and comes to rest again when the ship is past. That is, the motion of the water is not what is called steady motion, and, therefore, Bernoulli's principle does not apply. But the dynamic effects associated with a ship steaming through a body of still water are exactly the same as the dynamic effects associated with a steady stream of water flowing past a ship which is standing still, and in the latter case the fluid motion is steady and Bernoulli's principle does apply. Thus Fig. 8 represents a stream of water flowing past two ships. The velocity of the water is greatest between the two boats where the stream lines are most crowded. Indeed, the velocity of the water is greater between the boats than it is on the outer sides of the boats; therefore the level (pressure) of the water is greater on the outer sides than it is between the boats; and consequently the two ships are pushed toward each other by the high-level water on the outer sides.

FIG. 3.

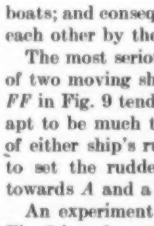


The Venturi tube.

The most serious situation arising from the attraction of two moving ships is illustrated in Fig. 9. The forces FF in Fig. 9 tend to turn the ships, and these forces are apt to be much too large to be overcome by the action of either ship's rudder, even if the helmsmen are quick to set the rudders properly. Therefore ship B turns towards A and a collision results.

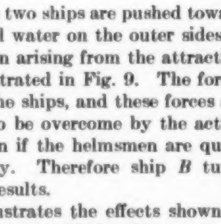
An experiment which illustrates the effects shown in Fig. 8 is to hang two smooth balls side by side, as shown in Fig. 10, with a space of about an inch between the balls; the balls are pulled together by blowing between them.

FIG. 6.



Ball and air jet.

FIG. 7.



Handle and air jet.

The Curved Flight of a Spinning Ball.—To analyze the effect of the air upon a moving ball, it is best to think of the ball as standing still with the air blowing past it, as shown in Fig. 12.

Fig. 11 shows the air whirl near a spinning ball; and Fig. 12 shows a blast of air streaming past a ball that is not spinning. Let us consider a combination of Figs. 11 and 12—that is, let us consider how a blast of air streams past a spinning ball. At a the stream and the whirl both give a velocity from right to left—that is, two causes are acting together at a to produce velocity from right to left. At b, on the other hand, the stream tends to produce a velocity from right to left, whereas the whirl tends to produce velocity from left to right—that is, two causes act in opposition to each other at b to produce velocity. Therefore the velocity at a is much greater than the velocity at b, as shown in Fig. 13. Therefore, according to Bernoulli's principle, the pressure of the air at b is greater than the pressure of the air at a, and consequently the spinning ball is pushed upward by the air stream or blast.

The dynamic effects in Fig. 13, where a blast of air blows from right to left past a spinning ball, are exactly the same as the dynamic effects in Fig. 14, where a spinning ball moves from left to right through a body of still air. That is to say, the spinning ball in Fig. 14 is pushed upward by the air, and therefore the ball travels in an upward curve, as indicated by the dotted curved arrow.

FIG. 4.

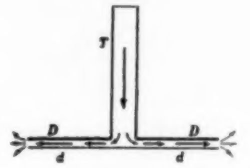


FIG 5.

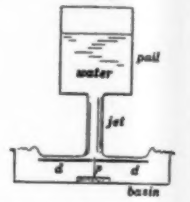


Diagram showing the disk paradox.

Let us call the foremost point N of the traveling ball the *nose* of the ball. *The traveling ball curves in the direction in which the nose of the ball is moving because of the spin.* Thus, if the nose of the ball moves toward the right with respect to a pitcher, the ball will curve to the right; if the nose of the ball moves upward (as shown in Fig. 14), the ball will curve upward, and so on.

Perhaps the best way to throw a curved ball for purposes of demonstration is to use a light ball of cork or pith, and throw it from a pasteboard tube, moving the tube somewhat as one would move a bat. The inside walls of the tube should be rough so that the ball will roll along the inside of the tube, and come out of the end of the tube with a rapid spinning motion.

Fig. 15 shows the curved flight of a high foul. The ball is set spinning rapidly as it glances off the bat, and instead of following the symmetrical dotted curve (which it would follow if it were not spinning) it actually follows the curve CC.

This curved flight of a high foul may be beautifully demonstrated by means of a light ping-pong ball or by means of an oak-gall. Throw the ball or oak-gall upward by the thumb as in shotting a marble, and as it falls it will curve in toward one's feet. This experiment must be performed in a closed room where there is no wind.

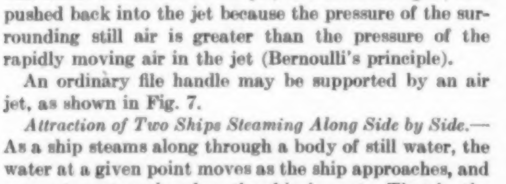
The Spit-Ball.—There is no reason why a sharp-pointed stick standing exactly vertical on a hard floor in a quiet room should fall one way more than another. Therefore the stick will not fall either way! That is good logic, but it is bad physics. The stick always does fall. The fact of the matter is that such a stick is unstable; and in the case of an ideally sharp stick standing perfectly vertical, an infinitesimal initial distrubance would be enough to start the fall in some direction, and then away she goes! We are here dealing with a kind of physical phenomenon in which the much-talked-of philosophical principle of cause and effect does not hold. When infinitesimal causes can determine finite differences in the ultimate trend of a phenomenon, then surely the principle of cause and effect is no more! Indeed, an infinitesimal cause is (in the limit) non-physical!

We here stand face to face with an entirely new branch of physical science, a branch which has existed for some years in the minds of some of our most advanced physicists, and a branch which is just beginning to be realized in researches concerning the discharge of electricity

*Reprinted from the Journal of the Franklin Institute.

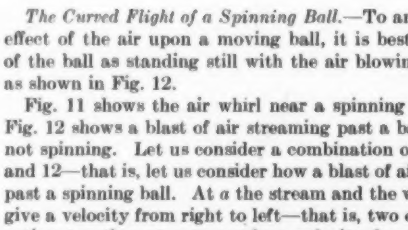
[1]A further limitation of Bernoulli's principle is exemplified by the motion of the fluid in a cream separator. The pressure is greatest near the outer walls of the rotating bowl where the velocity is greatest. Bernoulli's principle does not apply to rotational fluid motion.

FIG. 8.



A stream of water flowing past two ships.

FIG. 9.

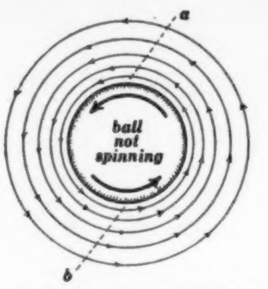


Attraction of two moving ships.

FIG. 10.

Experiment of hanging balls.

FIG. 11.



Air whirl produced near a spinning ball—air everywhere at rest except in so far as it is affected by the spinning ball.

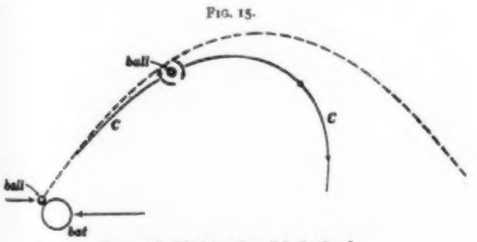
through gases: statistical physics. All correlations in this branch of physics must be sought for on the basis of statistical studies; the same thing never happens twice; and the old-fashioned idea of *cause and effect*, or the idea of *one-to-one correspondence*, or the idea of *law*, *in the sense of functional relationship* (as one may prefer to call it), gives place to chance and the laws of probability.

The older physics is sometimes called *macro-physics*, and the newer *micro-physics*, but this is distinctly misleading, because the largest-scale phenomena with which we deal in this world of ours belong to statistical physics—namely, weather phenomena. And the essential method in meteorology is the statistical method. Some little insight into atmospheric phenomena can be obtained by studying functional relationships, such as are expressed by Boyle's law of gases, the law of constant circulation in the vortex theory of fluid motion, the functional laws of radiation and absorption, and the functional relations of long-time and wide-space averages; but the thing which is now most needed in meteorology is the study and classification of storm types, the establishment of norms and probable departures therefrom, and, above all, the study of incipient stages of storm movements where very small variations may produce very large ultimate departures. If weather control is ever to be realized it must be by studying the possibilities of big consequences from small beginnings! Our Weather Bureau should employ, say, twenty of the most talented young men of highly-developed and rigorously-trained imaginative faculty, and set them to work studying storm data, averaging in time and space to discover norms, studying individual departures, and, above all, visualizing storm movements on a basis of the most minute study of details. No other method can ever lead to important results in meteorology.[2]

Consider a very smooth ball which is moving through still water without spinning. There is certainly no more reason why the ball should jump to the right than to the left. Therefore it must continue to move straight forward! That is good logic; but such a ball is no more subject to logic than is a sharp stick! The fact is that the ball does jump sidewise, and in a most irregular manner. This may be shown by dropping a smooth marble in a jar of still water. The marble goes nearly straight for several inches, and then suddenly jumps sidewise, as shown in Fig. 16. Similarly a smooth baseball jumps sidewise irregularly as it moves through the air, if the ball is not spinning.

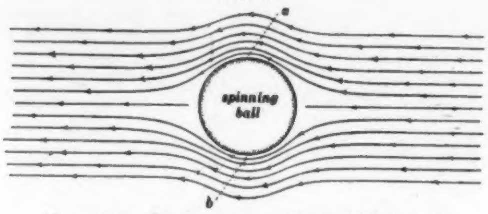
[2] See a very brief article by W. S. Franklin in *Science*, vol. xiv, pp. 496, 497, September 27, 1901.

FIG. 15.



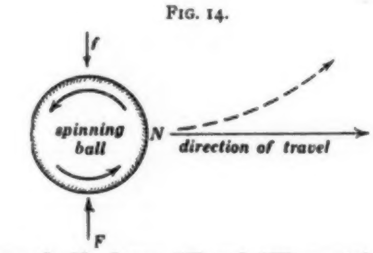
Curved flight of a high foul.

FIG. 12.



Air stream flowing past a ball which is not spinning.

FIG. 14.

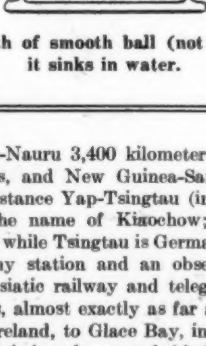


Unequal side forces "f" and "F" exerted on a spinning ball which is moving through the air.

Fig. 17 shows how a rapidly moving stream of air splits when it flows past a ball, and the dividing lines, or *vortex sheets*, *aa* and *bb* between moving and still air are unstable. The result is that the stream of air *aa* (or *bb*) spurts upward and downward in irregular succession. When the stream *aa* spurts downward it produces an upward force or reaction on the ball, and *vice versa*. That is to say, the irregularities of the streams *aa* and *bb* cause a series of irregular side forces to be exerted on the ball.

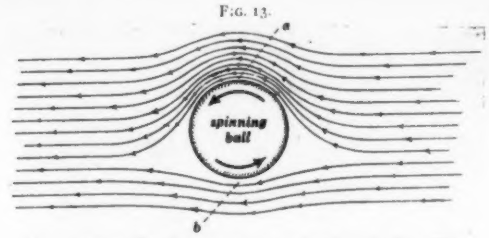
The dynamic effects associated with a ball standing in a stream of air as shown in Fig. 17 exist also when a ball moves through still air. Therefore if a ball moves fast enough through still air to produce unstable vortex sheets, the irregular sidewise spurts of the air as it flows around behind the ball will cause the ball to travel in an irregular zigzag path.

FIG. 16.



Irregular path of smooth ball (not spinning) as it sinks in water.

FIG. 13.

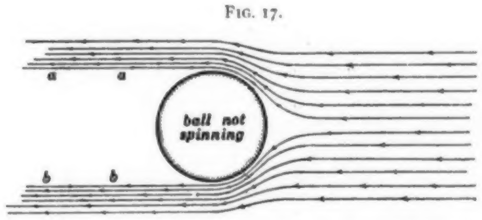


Air stream flowing past a spinning ball. The velocity is high at "a" and low at "b"; consequently the air pressure is high at "b" and low at "a," thus producing the unequal forces "F" and "f" in Fig. 14.

The instability and consequent irregularity of a stream of rapidly-moving fluid is exemplified by the sensitive fluid. Every one knows how an ordinary gas flame suddenly becomes turbulent and produces a roaring sound when it is turned up too high (velocity of gas too great), and when a gas flame is on the verge of becoming turbulent the least disturbance is sometimes sufficient to throw the flame over into the turbulent form. A sensitive flame can easily be made by drawing out a glass tube to give a smooth nozzle about a millimeter in diameter, and burning a jet of ordinary illuminating gas at this nozzle. When properly adjusted, the flame responds to a hissing sound across a large room.

The hissing sound of a high-pressure steam jet is due primarily to an unstable condition of the jet near the nozzle, an unstable condition which is somewhat similar to the instability of the vortex sheets *aa* and *bb* in Fig. 17; and this instability leads to an excessively irregular and complicated whirling and eddying motion in the jet. Indeed, a jet of gas or steam is infinitely complicated! Everyone concedes the idea of infinity which is based on abstract numerals—one, two, three, four and so on *ad finitum*—and the idea of infinity which is based on the notion of a straight line; but most men are concerned with more or less persistent or steady phases of the material world, their perception does not penetrate into the substratum of utterly confused and erratic action which underlies every physical phenomenon, and they balk at the suggestion that the phenomena of fluid motion, for example, are infinitely complicated and erratic. Surely the abstract idea of infinity is nothing as compared with the dreadful intimation of infinity that comes from things that are seen and felt. We are immersed in an illimitable sea of phenomena every element of which is infinitely complex, and every minute detail is essentially erratic.

FIG. 17.



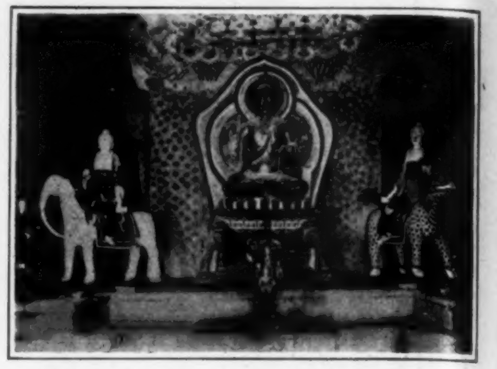
Showing how a rapid stream splits when it flows past a ball.

German Radiotelegraphic Stations in the Pacific

THE first German radiotelegraph station in the Pacific was opened in November, 1909, on Yap (or Uap) Island, in the Carolines, situated about 10 deg. N. and to the north of New Guinea. The station was built by the Telefunken Gesellschaft on behalf of the Deutsche Südsee Phosphat Gesellschaft, which has phosphate mines there, and about 500 kilometers west on Angaur, which belongs to the Palau Archipelago. Yap is connected with the cable system of the Deutsch-Niederländische Telegraphen-Gesellschaft (of Cologne) by three cables to Shanghai, in China, to Guam (in the Marianne Islands, belonging to the United States), and to Menado (on Celebes, Dutch East India). For this reason Yap was selected as a radiotelegraphic center, and further stations have now been erected at Rabaul (seat of the Governor of German New Guinea, who is also Governor of the large Bismarck Archipelago), at Nauru (in the Marshall Archipelago, which extends far to the north of the Equator, while Nauru itself is on the Equator), and at Apia, in Samoa (14 deg. south); a station on the already-mentioned Angaur Island had been built at the same time as that on Yap. The distances worked are considerable. Yap-Rabaul is 2,200 kilometers, Yap-Nauru 3,400 kilometers, Nauru-Samoa 2,700 kilometers, and New Guinea-Samoa 4,000 kilometers. The distance Yap-Tsingtau (in Shantung, also known under the name of Kiaochow; but Kiaochow itself is Chinese, while Tsingtau is German, and possesses a radiotelegraphy station and an observatory, and is joined to the Asiatic railway and telegraph system) is 3,650 kilometers, almost exactly as far as from Clifden, in the west of Ireland, to Glace Bay, in Newfoundland. The station at Apia is to be opened this Spring, the other stations are already working. The stations are equipped with 60 horse-power oil engines, and with umbrella antennæ 120 meters in height, to work with an energy of 25 kilowatts or 30 kilowatts, and with waves ranging from 300 meters up to 2,000 meters; the ordinary wavelength for signaling to ships is 600 meters. Smaller coastal stations for T antennæ and energy of 5 kilowatts are being added. The German Telegraph Department has not proceeded directly in this enterprise. A concession has been granted to the two companies already referred to, the Telefunken-Gesellschaft and Deutsch-Niederländische Telegraphen-Gesellschaft, which, for building and working these stations, have combined with the Deutsch Südsee-Gesellschaft für Drahtlose Telegraphie. The combination was effected in August, 1912, and the service is under the control of an Imperial commissioner. The co-operation of a cable company with a radiotelegraphy company will forestall rivalry between these two telegraph systems. We may supplement this note by a few statements on other radiotelegraphy stations in German colonies, almost all of which are now equipped. In German East Africa there is a coastal station at Dar-es-Salaam, and two stations are at Nuansa and Bukoba, on the Victoria Nyanza. Cameroon has a station at Duala; Togo, one at Toblekohve, near Lome (not yet open); and German Southwest Africa, stations at Swakopmund and Lüderitz Bay. Further stations are contemplated, and an agreement will probably be made with the Netherlands government as to the question of a station at Sumatra, in the East Indies, to serve as intermediate station between East Africa (Dar-es-Salaam) and the Pacific islands (Yap). The distance between East Africa and Sumatra would be 8,000 kilometers, while the farthest distance, so far covered experimentally at night-time, is Nauen-New York, 6,500 kilometers. Nauen and Togo, 5,500 kilometers, have communicated with one another at daytime.—*Engineering*.

Interior of a grotto of the ming-ui or "thousand houses" (seventh century).

Terra-cotta bas-relief of Touen-houang (ninth century).



Buddha on his throne in grotto of Touen-houang. Side statues recently renewed.

Buddhist Art in Eastern Turkestan

The Pelliot Archæological Expedition

By the Paris Correspondent of the Scientific American

ORIENTALISTS consider that the recent finds which have been made in the sands of Turkestan, consisting of numerous vestiges of a civilization antedating the conquest of this country by Islam, form one of the leading epochs in this branch of archæology. The specimens belong to the period lying mainly between the seventh and the ninth century of our era, the conquest having taken place about the year 1000. This part of Asia was the center for the spread of Buddhism into China, and at the beginning of our era, the Hindoo religion started from the upper Indus and by way of the Pamirs and Karakorum it reached the limits of the Celestial Empire. Following this, there was a corresponding spread of the forms of art which existed in northwest India, this being a Hellenistic art of which numerous specimens are now extant. We illustrated this form, which is characterized by the influence of Greek upon Hindoo art, in a preceding article, and typical works of the kind have been found at Gandhara.

In the specimens which the French expedition found in Turkestan, and which are the subject of the present description, it is noticed that the style is closely related to the above-mentioned Græco-Buddhist art. As M. Foucher states, the originality and interest of these specimens consist in an intimate union of the antique and the Oriental spirit, in the fusion as it were of the Buddhic legend in Occidental molds. Thus we see the combination of a classic form and a Buddhist foundation idea, or the adaptation of Greek or Hellenistic technique to strictly Hindoo subjects. As we examine these remains, we observe that as to execution and handling, the ideas taken from India bear but a small proportion, but if the *motifs* are not strictly native they are not, on the other hand, purely Greek. It might be said that they occupy a position midway between Mediterranean classicism and Hindoo inspiration, and these two tendencies are about equal.

Owing to the attention which archæologists have been giving to this subject for the last twenty years, as well as the numerous excavations which are made, it is possible to trace the transmission path of Mediterranean art into the extreme regions of Asia by way of Assyria, Persia, Bactriana, Gandhara, eastern Turkestan and northern China. In 1889 Capt. Bower, an Englishman, purchased at Kutchar a manuscript which was recognized as a medical text in Sanskrit, of Buddhic origin, and this appears to be the first specimen showing Hindoo influence in Turkestan brought to the knowledge of European archæologists. As the greater part of the Buddhist manuscripts had disappeared from India proper, the discovery of the Bower manuscript led to the hope that the originals would be found in the sands of Turkestan. The Russian consul and the English agent at Kachgar thereupon lent themselves to the task of collecting all the manuscripts and objects which treasure-seekers had found in the sands, and they sent these to St. Petersburg and Calcutta. In 1897, the Academy of Sciences, of St. Petersburg, sent Dr. Klementz into the Tourfan region, and following this a German expedition set out under the direction of Dr. Grünwedel. On the other hand, the well-known Swedish explorer, Sven Hedin, had discovered a certain number of "dead cities" in the southern part of the desert. In 1900, the government of India sent an expedition to the Khotan region under Dr. Stein, and it brought back numerous Hindoo and Thibetan manuscripts as well as works of art of an Iranian and Græco-Buddhist character.

Bas-relief of Toumchoug (eighth century), showing some destruction in parts.

Nirvana of Buddha (ninth century); statues of deciples, recently renewed.

These important discoveries awakened the interest of Orientalists over the entire world, and as the result of the movement, the Hamburg Congress founded, in 1902, an international association for historical, archæologic, linguistic and ethnographic exploration of central Asia and the extreme Orient. France was among the last countries to enter actively into the work, but finally a scientific expedition was sent out in 1905 under M. Paul Pelliot, a leading archæologist and professor of Chinese language and literature at the French School of Extreme Orient, at Paris. The object of the expedition was mainly to carry on researches concerning vestiges of pre-Islamic Buddhism, but measures were taken to make other scientific observations as well, such as natural history, astronomy and cartography, and in this he was aided by Dr. Louis Vaillant for observational research, and also by M. Ch. Nouette for the photographic work, to whom we are indebted for the originals of the accompanying illustrations.

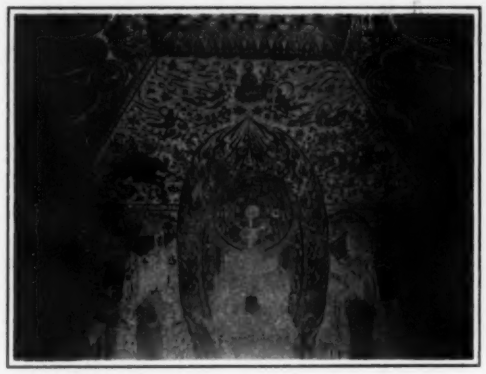
The first important archæological labor of the expedition was carried on at Tumchong between Kachgar and Kutchar, where Sven Hedin had observed some ruins, and these proved to be the remains of a Buddhist monas-

Altar of Buddha in Touen-houang, about the year 700.

Statue in a grotto of Touen-houang (ninth century).

Fresco of a grotto in Touen-houang (seventh century). Monk added (ninth century).

Statues near Touen-houang (eighth century) recently repainted.



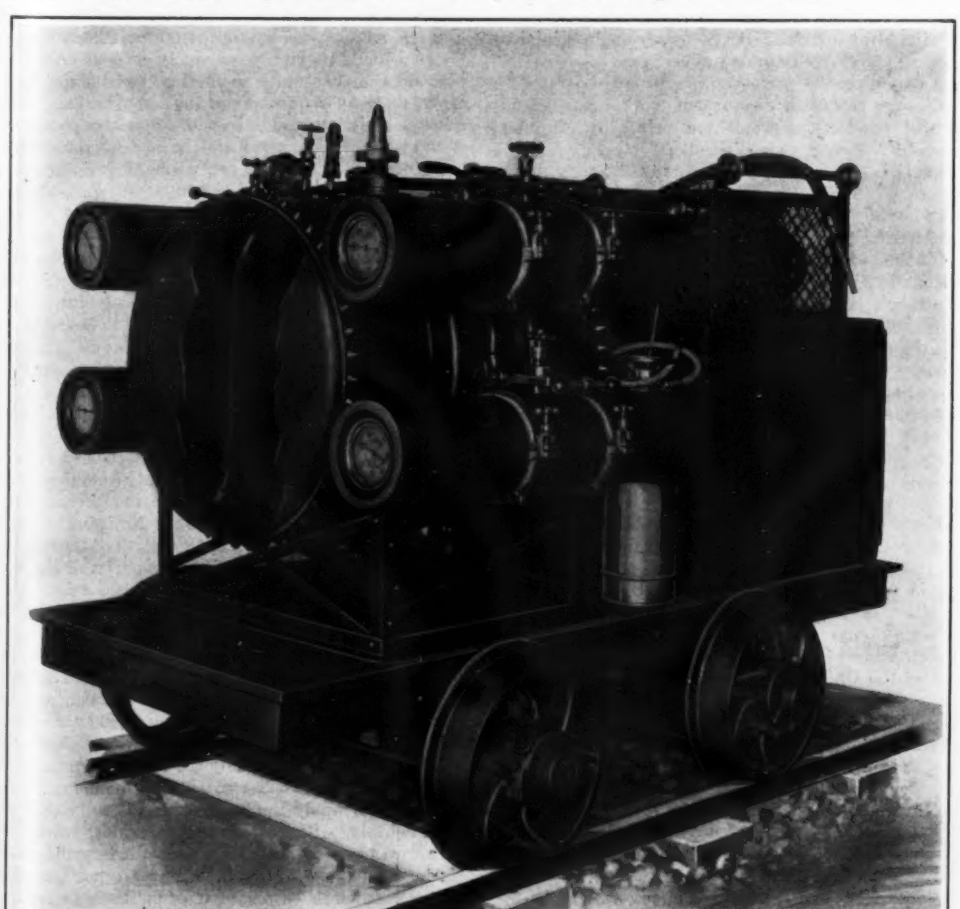
Fresco of a Buddhist sanctuary in grotto of Touen-houang.

Modern statues of the grottoes of Touen-houang.

tery. Proceeding with excavations at this point, M Pelliot here passed six weeks and employed 25 to 30 workmen per day, first finding great numbers of statues, bas-reliefs, statuettes and pottery which showed undisputed Hellenic affinities. Then the entire plan of the temple was found and drawn up, and in this place there was discovered a gallery containing bas-reliefs in hardened clay. These are artistic and historical specimens of the first rank, and they show the close relation existing between the sculptors of Chinese Turkestan and those of northwest India, bringing out the influence of the Hellenistic style in central Asia. Leaving this spot with an extensive collection of specimens, the expedition proceeded to the oasis of Kutchar, where the Russian archæologist Berezovski had already been at work. The French expedition carried out extensive excavations at this site, in the first place at the ancient temple of Duldour-aqur, and unearthed a collection of numerous manuscripts which was agglomerated with sand and mineral salts. The texts of these manuscripts were in Brahmi writing, and also in an undetermined idiom, and are now being deciphered. After this, M. Pelliot commenced some most interesting work upon the *ming-ui* or "thousand houses," as expressed in the Turkish language, or, in Chinese, the *tsien-fo-tong*, or "grotto of the thousand Buddhas." These are artificial grottoes hollowed out of the sandstone, loess and alluvial conglomerates, and fashioned as Buddhic sanctuaries, these dating before the arrival of Islam. The expedition took numerous photographs of the *ming-ui* and their mural paintings, which are of a remarkable character, at different places in the neighborhood of Kutchar. The next place chosen by the party was Touen-houang, which yielded an important series of finds. At 12 miles distance from this town, several tourists had noted more than 500 sanctuaries, or Tsien-fo-tong, and upon arrival at this spot, M. Pelliot recognized that it had not as yet been explored by archæologists, so that the party went enthusiastically to work to uncover the sites or to explore the grottoes. It was found that the paintings and sculptures had remained intact and were not disfigured by the Islamic invaders, as had happened in Kachgaria. At first sight, he noted traces of several artistic epochs. As this locality lies at the extreme west of Kan-sou, which is a province of the Celestial Empire on the border of Turkestan, it can be considered as one of the meeting places of Græco-Hindoo and Chinese influences. The expedition spent a considerable time in examining these grottoes, placed as they are at the confluent of the two great civilizations of the globe, and M. Pelliot had the good fortune to make an extensive find of ancient manuscripts in an underground library. These manuscripts were in Thibetan, Chinese, Sanskrit and Ouigour, and dated from the seventh and eighth centuries of our era. After examining this site and securing specimens, the work of the French expedition practically came to an end in 1908. After three years of observations and excavating work, the expedition returned to France with specimens of the greatest value for orientalists of the entire world. The specimens include 4,000 photographs, numerous plaster casts of steles, and more than 80 cases of sculptures, paintings and manuscripts. A part of this extensive collection has now been placed on exhibition in the Louvre at Paris.

A New "Mine Type" of Chemical Fire Engine

The mine type air pressure chemical fire engine is an entirely new device. The chemical tank, of any desired capacity, is mounted on a steel frame and can be placed on a mine car or other suitable vehicle. There is no complicated mechanism, and nothing inside the tank except the solution and the discharge pipe. Two or more air cylinders, holding compressed air under pressure of 1,000 pounds to the square inch, are mounted on the apparatus. Simply by opening one valve, the pressure from the air cylinder enters the chemical tank and forces the stream through the hose, where it is controlled by a shut-off nozzle. One air cylinder will empty the chemical tank two or three times. Any pressure desired may be obtained, and a uniform, powerful pressure automatically maintained, by means of a reducing valve through which the compressed air must pass before entering the chemical tank.



A new "mine type" of chemical fire engine

The great advantage of this type of apparatus is the fact that the chemical tank may be carried completely filled with solution, no "air space" being required. Any desired chemical solution, or even plain water, can be employed, permitting the use of non-freezing solutions and solutions having much greater fire-fighting efficiency than the ordinary chemical streams. The pressure is powerful and uniform from first to last. Unused portions of the chemical solution do not have to be thrown away and wasted, as is the case with all other chemical fire apparatus; but the tank is simply refilled to replace the used portion.

By changing the nozzle and solution, the apparatus can also be used as a spraying machine for wetting down the mine haulage-ways and other dry and dusty places, with fire-proofing, dust-laying, or white-washing mixtures. The operation is simpler, quicker and more economical than with the usual type of chemical fire engines in which soda and acid are employed. The pressure is more powerful and more uniform, and all the fire-extinguishing properties of the solution are used on the fire, none being employed and wasted for purposes of pressure.

The principle (in other forms of fire apparatus) has been thoroughly tested by actual service in numerous fire departments and has been approved and purchased by the United States Government.

Microbian Life

Microbian cultures are often very difficult. M. Adrien Lucet, member of the Academy of Medicine, has just shown that a regular agitation or shaking of the liquid mediums used in bacteriology, contrary to the opinion that is generally admitted, acts favorably on these infinitely little creatures. By making these bouillons undergo a slow and continuous movement he has, in fact, been able to obtain cultures as many as eight times more abundant of the microbes of cholera, typhus fever, carbuncle, diphtheria, the glanders, dysentery, and even of lockjaw, the microbe of which can only be cultivated without the penetration of any air. It was M. Chauveau who communicated M. Lucets' study to the Academy.—*Chemical News.*

Aerial Mail Service in the United States was first tried in 1911, and since that time the Postoffice Department has authorized the carriage of mail by this method (without expense to the Government) in fifty-four instances. The estimates of the Department for 1915 include an item of $50,000 for an experimental aerial mail service. The postmaster general believes that there are sections of the country where, on account of topographical conditions, this class of service would prove advantageous.

The Industrial Need of Technically Trained Men

Sanitary Engineering

R. Winthrop Pratt

R. Winthrop Pratt, the author of this article, received his first training at the Massachusetts Institute of Technology. He has served as Assistant Engineer for the Massachusetts State Board of Health, as Chief Engineer for the State Board of Health, and as Director of Sanitary Engineering of the Republic of Cuba, having been called by the Cuban Government to assist in continuing the work of improved sanitation which was begun at the time of the American intervention at Cuba.

At present he is Consulting Engineer to the city of Cleveland, in charge of the Sewage Disposal plans and investigations, and also of the preparation of the detailed plans for the new water filtration plant, the construction of which has recently been started.

Mr. Pratt is associate author of a text book on Sewage Disposal which is probably used in all colleges where courses in Sanitary Engineering are given. He is a member of the American Society of Civil Engineers, of the New England Water Works Association, as well as of other local engineering societies.—EDITOR.

SANITARY engineering comprises the design and construction of all engineering works which are built for the purpose of protecting the public health. In other words, sanitary engineering relates to the practical application of the principles of public hygiene, through the medium of civil and hydraulic engineering, combined with chemistry, biology and physiology. The term "public hygiene" may be defined as "the science and the art of the conservation and promotion of the public health." It has for its functions the prevention of premature death and the promotion of life, health and happiness in communities through the elimination of unfavorable environmental conditions.

Speaking more definitely, the field of sanitary engineering comprises the installation and maintenance of public water supplies, water purification works, sewage systems, sewage treatment works, and garbage disposal plants; also the ventilation, heating and plumbing of public and other buildings. The last named work, however, is generally considered as being in the field of the architect, ventilating engineer or plumbing expert.

Sanitary engineering as it is now considered did not come into prominence until after the development, about 35 years ago, of the science of biology, which resulted in the working out of the principles governing the causation and transmission of such diseases as typhoid fever, cholera, malaria and yellow fever. The greatly increased concentration of people in cities and communities during the last 30 and 40 years has created an urgent demand for sewerage systems and water supplies; and the development of tropical countries has called for the highest skill of the sanitary engineer. The most notable example of the importance and effectiveness of sanitary works and well administered sanitary laws is the Panama Canal, which could not have been built but for the elimination or control of the causes of the infectious diseases which had existed in the canal zone for years past.

A recent illustration of the possibilities of good sanitation, combined with good medical service, is afforded by the National Encampment at Gettysburg, last July, of the Northern as well as the Southern veterans of the Civil War. Gettysburg is a small town of not over 4,000 people. Previous to the encampment, it had a public water supply, but no modern sewage disposal system. To safely care for about 100,000 old men, many in poor health, in such a small place, and in the hottest weather, was a difficult problem, and authorities estimated that at least 500 deaths might be expected. The United States and Pennsylvania State health officials took charge of the sanitation; and with ample funds at their command, secured proper water supply and sewerage facilities, built rest rooms, hospitals and dispensaries and provided an organization of physicians, nurses and inspectors. As a result, the number of deaths during the encampment was only 10 instead of 500, which was lower than the rate would have been if the soldiers had stayed at home.

TRAINING AND QUALIFICATIONS OF THE SANITARY ENGINEER.

The most prominent sanitary engineers now practising in this country have obtained their training in different ways. Some have been first trained as civil or hydraulic engineers and have later studied or practised chemistry and biology to an extent sufficient to make them well qualified sanitary engineers. Others have begun as chemists or biologists and have later obtained engineering knowledge and training. This latter class have succeeded in most instances by virtue of their natural ability and personality, rather than by virtue of having had their preliminary training in the laboratory instead of through engineering work.

In view of the usual demands and responsibilities incidental to the practice of sanitary engineering, it would appear that the more logical programme would be for the prospective sanitary engineer to secure first a fundamental training in civil and hydraulic engineering, and at the same time, or later, obtain such knowledge of chemistry and biology, as well as of the various branches of public health work, as may be necessary to properly qualify him for his profession. On the other hand, there is a certain group of sanitary engineers who are called to positions involving the maintenance and operation of water purification and sewage disposal works; and such men should have fundamental laboratory training in chemistry and bacteriology.

Courses in sanitary engineering are now given at some of the leading colleges, such as Massachusetts Institute of Technology, Carnegie Technical School, Harvard, Yale, Cornell and Columbia universities and the State universities of Ohio, Illinois, Michigan and other States. These courses comprise a thorough training in civil engineering, the design of structures and bridges, hydraulic engineering, as well as enough laboratory practice to enable the sanitary engineer to understand the principles of chemistry and biology, and at least to co-operate with and interpret the results of the researches of chemists and biologists. Particular attention is given in these courses to the sanitary side of the questions of water supply, sewerage, drainage, and methods of purifying water and sewage, the relation between drinking water and disease, and other questions relating to the public health.

Quite recently, there has been established, jointly by the Massachusetts Institute of Technology and Harvard University, a School of Public Health to which graduate students only are admitted; and which confers upon its graduates the degree C.P.H. (Certificate of Public Health), and qualifies them to hold administrative positions in public health work. Students may enter this School of Public Health after receiving either a degree in sanitary biology, a degree in medicine, or, with certain qualifications, a degree in sanitary engineering. The course after entrance is such as to supply the necessary medical knowledge to those entering with degrees in engineering or biology; and the necessary engineering and biological knowledge to those trained in medicine, so that those obtaining the degree of C.P.H. will be fitted to take charge of health department work involving the practical application of all the principles of public hygiene or "preventive medicine."

DEVELOPMENT OF SANITARY ENGINEERING IN THE UNITED STATES AND ABROAD.

The last 30 years have been largely a period of research in matters relating to the treatment of water and sewage. One of the pioneer steps in this country was the establishment in 1890, at Lawrence, Massachusetts, by the State Board of Health of that State, of an experiment station for the purpose of studying and working out methods of water purification with an idea of giving, to the cities and towns of Massachusetts, advice relative to securing safe water supplies and protecting streams against pollution. The results of the experiments at Lawrence have become classic in the art of water and sewage purification; and have been used as a basis in the design of large works in Massachusetts and in other States as well as abroad.

The value of the Lawrence researches, as regards water purification, were somewhat limited by reason of the fact that river waters in Massachusetts were different from those in the Middle West. In 1897 and 1898, therefore, the cities of Louisville and Cincinnati, in order to thoroughly study their respective problems of water supply, conducted extensive experiments on the treatment of the Ohio River water; and these have added greatly to our general knowledge on this subject. A few years later, the cities of Philadelphia, Pittsburgh and New Orleans also conducted tests on treating their water supplies; and the results of these tests have served as a basis of design for water filtration works, since constructed not only in the cities mentioned, but also in other places. Several cities also have conducted tests on sewage treatment under their respective local conditions; and the total amount spent in this country to date for making these researches and tests equals about $1,000,000.

Owing to varying conditions in different parts of the United States with respect to geological and topographical and other conditions, methods of sewage and water purification suitable for one place may not be satisfactory for other places. As a result of numerous studies, however, the methods of water purification have been fairly well standardized during the last 30 years, so that an engineer may now be safe in designing a plant to cover a given set of conditions. The same may be said of sewage treatment methods, although probably to a less extent.

As regards the disposal of garbage, this question has been given less attention by independent consulting engineers than have water and sewage problems; and the progress in garbage treatment methods has been made largely by manufacturers who have worked out their own patented devices. More recently, however, city officials and others responsible for the solution of garbage problems have come to feel that it is worth while to call in consulting sanitary engineers to study the problem in an unprejudiced manner, rather than to deal only with patent owners and manufacturers of apparatus.

Summing up briefly the progress which has been made in sanitary engineering in England and Europe during the last 40 years, it may be said that owing to the more thickly populated districts, much more study has been given to water, sewage and garbage problems. Water filtration and sewage treatment works were installed by London, the world's largest city, long before any of the American cities have thought of these problems. A number of German cities installed water filtration works some 20 years ago. The number of experienced sanitary engineers in England, and possibly in Germany, is therefore relatively greater than here, and their work has been of great value to American engineers both as affording data as to efficient methods, as well as equally important data relative to the methods which have been failures.

The Protection of Buildings Against Lightning

THE electrical atmospheric discharges to which a building is exposed are of two sorts. The first results from the gradual increase of potential between the cloud and the building; when this difference is sufficient to overcome the critical resistance of the air interposed, the discharge takes place; this discharge, generally oscillating, is regulated by the known laws of electricity relating to resistance, inductance and capacity. The second sort is a violent secondary discharge which is produced in the neighborhood; it is hardly influenced by ordinary lightning conductors, and to protect the building with them the roof would require to be largely covered with metal. Lightning discharges are oscillating, and the oscillations are exceedingly frequent, from 100,000 to perhaps several millions of periods to the second. Now the electric constants of these conductors are entirely different to those frequencies to what they are normally; the impedance especially is considerable. Little is known concerning the electrical conditions of atmospheric discharges. Generally the discharges between the clouds and the earth are of a very high voltage, and consequently put a considerable energy in movement. This energy is transformed partly into Joule heat and partly into electric radiation emitted in the form of waves. The fraction of energy thus radiated depends upon a crowd of circumstances, particularly it increases with the frequency. If the discharge takes place between the cloud and a thin rod of copper, for a frequency of a million periods, it is calculated that the quantity of energy radiated may be fifty times greater than that transformed into heat. Nevertheless there is always uncertainty as to the amount of frequency. If it is admitted that the discharge after having reached the rod of the conductor is influenced by the characteristics of this rod, the length of the rod for a height of 15 meters would give frequencies of the order of five millions. If, on the contrary, it is considered that the length of the wave is regulated by the distance of the cloud from the earth, the frequency would be much lower, 250,000 periods, for example, for clouds at 600 meters. In order to render good service, the lightning conductors must be well installed. If not they are more dangerous than useful. A lightning conductor of great height and with some defect (such as wire broken at one point, badly joined, or badly set into the ground) may attract dangerous discharges on to the house. It is necessary to supply the building that is to be protected from lightning with a large number of rods, which seems to assure the best outlet for the secondary discharges; six for a house of 30 by 15 meters are not too many. These rods must be placed outside the house, and as much as possible isolated from all the metallic canalisations of the building. In town it is good to employ copper rods for lightning conductors. In the country, galvanized iron may be employed; it is advisable to give it the form of a cylinder or a tube.—*Chemical News.*

The Elements of Fatigue*

By Percy G. Stiles

No fact of life is more familiar than the development of fatigue. We anticipate that the vigorous and continued employment of a set of muscles will lead to sensations of discomfort, then of difficult effort, and, finally, of utter inability to continue the action. We expect to see parallel objective conditions: progressive loss of speed, force and certainty of movement. The physiological changes which attend this decline of efficiency are far more complex than would at first be assumed. To enumerate them and to assign to each its proportionate share of the total effect has been a fascinating task and it is one which has not yet been completed.

The evolution of energy by a contracting muscle is limited by the store of available fuel. This is as strictly true for the living tissue as for a locomotive. In some respects the muscle is more like a machine-gun with a definite supply of cartridges. Either analogy is quite faulty, but if we rely on such comparisons provisionally we shall be inclined to infer that fatigue indicates a dwindling stock of fuel or ammunition. We must not forget, however, that in the normal body fresh supplies are offered to the working organs by the passing blood-stream. Exhaustion is postponed accordingly and may not threaten at all if the degree of activity is moderate. Our best illustration of such renewal is found in the heart; the diaphragm approximates the same condition since it probably never fails to bear a part in the inspiratory movements.

Consumption of fuel in living or lifeless surroundings is attended with the generation of oxidized products. If such compounds are not promptly removed they will impede the fundamental chemical reactions of the contracting muscle. Fatigue, then, may be brought on by inadequate removal of wastes as well as by a shortage of energetic material. It becomes evident that an abundant circulation increases muscular endurance not only by providing fresh fuel but by dispersing the end-products—and perhaps the by-products—of the decomposition process. In fact it is commonly held that the failure of contraction usually occurs as a result of an accumulation of such substances and becomes absolute while much fuel yet remains in the cells. This conception makes fatigue an intoxication rather than an exhaustion and is in accord with the experience that fatigue of certain muscles spreads somewhat to others not used.

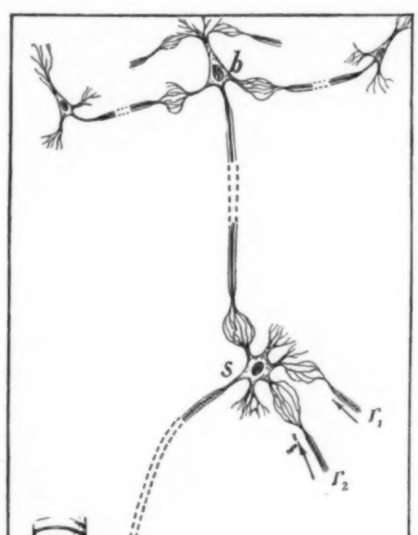
Laboratory experiments are easily devised which shall single out for observation the facts of true, localized muscular fatigue. In life the mechanism at work includes nervous as well as muscular elements and we have to consider the possible susceptibility of the former as well as the latter to the depressing consequences of their own activity. The resistance to fatigue exhibited by a man performing voluntary movements is not necessarily a measure of his muscular resources; it may be limited by conditions arising in his nervous system. It is of the utmost interest to discover the weakest link in the chain employed. We cannot make much progress in this direction until we shall have pictured the related parts which constitute a simple neuro-muscular mechanism.

A muscle is composed of a host of associated fibers of microscopic diameter. Each of these may be regarded as a muscle in miniature. It is a thread-like affair averaging an inch or more in length. About midway between its extremities it is tapped by a filament derived from the nerve governing the muscle in question. The muscle-fiber is a chemical engine; the function of the connected nerve-fiber is to throw it into action. One is reminded of the electric wires by which a torpedo is exploded. Where the nerve-substance seems to blend with that of the contractile muscle-protoplasm there appears to be an intervening structure differing from either. This junction is referred to as the motor end-plate.

If we could trace the course of a selected nerve-fiber back from an end-plate to its place of origin we should be led within the confines of the central nervous system. If the fiber were one which terminated in a leg muscle it would be found to spring from a curiously branched cell in the gray matter of the spinal cord. The same would be true of a fiber terminating in the arm, but in this case the cord-cell would be higher up. The muscles of the head are presided over by cells in the brain. Still retaining the crude analogy of the torpedo and its connections we find the nerve-cell standing for the battery which generates the current used to bring about the explosion. Under the terms of this comparison the end-plate is a priming appliance to transmit the effect of the nerve impulse to the unstable substance of the muscle. Any such attempt to compare the living fabric with artificial systems does violence to detail and must be regarded as symbolic rather than literal in character.

In the light of what has been said it will appear that fatigue may conceivably result (a) from changes in the working muscle, (b) from declining efficiency of the end-plate, (c) from alterations in the nerve-fiber, (d) from the decomposition processes in the nerve-cell. One of these theoretical possibilities may be ruled out. This is (c) in the series above; there is no doubt that of the several elements the nerve-fiber is the least subject to fatigue. Among the others it is commonly held that the end-plate is particularly liable to deterioration and that it is the diminishing utility of this transmitter which practically cripples a muscle after a certain period of vigorous use. It has been suggested that the end-plate bears a degree of resemblance to the safety fuse so often introduced in connection with electrical fixtures. This is to say that inquiry resulting from over-stimulation may be expected to fall upon this structure (which may be supposed to be easily renewed) and not to affect so readily the elaborately organized protoplasm of the muscle-fiber or the nerve-cell.

Most discussions of the subject of fatigue have been limited to the elementary mechanism just sketched. But when we are dealing with the intact organism and not with laboratory preparations there are additional matters to be considered. The nerve-cell which is the immediate source of excitation is not self-stimulated. The responsibility for its discharges is to be referred back to the activity of other cells so placed as to play upon it. In the case of those contractions which we regard as voluntary the cord-cells are known to be spurred to their work by cerebral cells. As soon as we include this new order of nervous units we find that we have to recognize further possibilities in the distribution of fatigue. We are called upon not only to estimate the extent to which true brain fatigue may figure in the observed result but to ascertain also whether the point of functional union between one nervous element and another may become impaired for its work as may the end-plate between nerve and muscle.



A simple neuro-muscular mechanism. (*f*) is a muscle-fiber. (*e*) is the end-plate through which it is stimulated. (*s*) is the motor cell in the spinal cord which sends out the impulse. This cell is subject to excitation —or perhaps to restraint—through its several synapses. Of these three are shown fully developed: (r_1) and (r_2) are paths of approach for sensory impulses such as Forbes employed, the remaining path is from the cerebral cell (*b*). The efficiency of this brain-cell in typical "voluntary" action is probably dependent upon the number of sources from which it is stimulated. Four of these are represented.

The "point of functional union" just mentioned is covered by the convenient word "synapse." The fact has lately been established that the synapse has to be reckoned with in any full treatment of the incidence of fatigue. It is very probably a link of inferior endurance and by its early refusal to conduct stimuli it may be assumed to protect the adjacent cells from excessive wear and tear. The symbol of the safety fuse is at least as legitimate for the synapse as for the end-plate.

We have traced the causation of voluntary muscular movement back from the muscle to the motor nerve-cells directly in connection with it and thence to cells of higher position in the nervous system. It is found to be difficult to account for the activity of these higher cells save on the assumption that they in their turn are goaded through synapses that place them in relation with still other working units in the brain. Whither are we led when we pursue as far as possible this shifting of responsibility for stimulation? Most authorities are agreed that we are obliged, in the last analysis, to conclude that the primary cause of the serial process is found in the influence of external conditions upon the receptors or sense-organs of the body. This is equivalent to saying that all muscular activity partakes very largely of the nature of reflex action. The psychological difficulties entailed cannot be dealt with here.

The emphasis lately placed upon the importance of the sensory side for efficient muscular performance has led to the question whether fatigue may not, in common experience, be due to changes on the route of the in-flowing as well as the out-flowing impulses which traverse the nervous system. We are compelled often to acknowledge that our fatigue is more accurately to be described as *disinclination* than as *incapacity*. To confess this is to express the belief that the motor mechanism still has power to work but that the sensory accompaniments have taken on a deterrent instead of a reinforcing character. We may conceive that the motor cells either in the brain or the cord—perhaps in both—are simultaneously prodded and restrained by different currents. The restraining or, technically, inhibitory influences become stronger with continued work while the positive stimulation is likely to flag.

Fatigue, when due to the fact that the inhibitory effect has become quite equal to the stimulation, will evidently disappear in part if new currents of an exciting sort can be supplied from without. This is exemplified by the power of emotional appeals, especially threats, to urge on a weary runner. Even more obviously it is the basis of the effect of blows. Yet the same principle may be recognized when the affective tone of the extra sensory application is wholly pleasant: for instance, in the postponement of fatigue for dancers whose whole environment encourages continued activity.

A reference in conclusion to a specific research will give coherence to much that has been said above. Alexander Forbes has shown (in cats) the following facts. A certain muscle is chosen for study and two sensory nerves are found, either of which can be employed to secure a reflex contraction of the muscle. One of these is stimulated persistently until the reflex fails. Stimulation applied to the other sensory path, immediately after, produces a vigorous reflex. What seemed to be total exhaustion is shown to be merely a failure of one particular inward route. Forbes locates the fatigue in his experiments in certain synapses between sensory and motor units of the spinal cord. He has simplified the conditions of his trials by eliminating the brain entirely and observing reflexes which are mediated through the cord alone.

Let us consider in what respects the human system is different at the end of a long day's walk from what it was in the morning. It doubtless presents many peculiarities which we have not hinted at. Altered secretory activities have influenced the composition of the blood; there has been an increase of lymph in many regions. The heart has been characteristically modified in its action. Without attempting to suggest other features we may summarize those which we have been discussing. The muscles contain less available fuel than they did. They are narcotized to some extent by their own chemical products. These products have been spread through the circulation and are very likely acting as depressants within the nervous system. The end-plates have suffered particularly and transmit with difficulty the impulses sent from the cord.

Fixing our attention upon the central axis itself we find that cellular fatigue there is a possibility but that exhausted synapses are more likely to be to blame for the sluggish reactions witnessed. Hence, to call out the last reserve of power, new means of sensory stimulation must be brought to bear. If our imagined subject is a tired soldier he may be carried along for a time under the sway of martial music. When that agency fails because its avenue of approach to the motor centers is choked, a pistol held to the head may compel him to continue his painful progress still longer. It becomes clear that if our fatigue were wholly a motor impairment, no fresh incentive to resist it could help at all. A playful trial of endurance would establish the same record as a struggle to escape impending death.

Note.—One qualification may be necessary. The extensive nervous processes which accompany emotion may cause the extra formation of adrenalin and perhaps direct the metabolism in other ways to favor muscular performance. But this does not invalidate the truth that changes in the form of sensory stimulation may reveal stores of strength where apparent exhaustion prevailed.

*Reproduced from *Science Conspectus*.

Stabilizer for Aeroplanes.—Otto Albin Budig of Lille, France, has patented No. 1,083,347 an automatic stabilizing apparatus for aeroplane in which a concavo-convex hollow plane is arranged with its convex wall downward and having a slot which communicates with a cylinder so that the wind of the machine creates a vacuum in the hollow plane, and a piston in the cylinder is connected with an elevating rudder so that the rudder is operated by the vacuum created in the concavo-convex hollow plane.

Fig. 1.—At work upon the site of lock and dam No. 17, as seen from cofferdam, looking toward abutment. Excavation for about forty per cent of the dam site and the entire abutment foundation and back-filling of all walls is yet to be done.

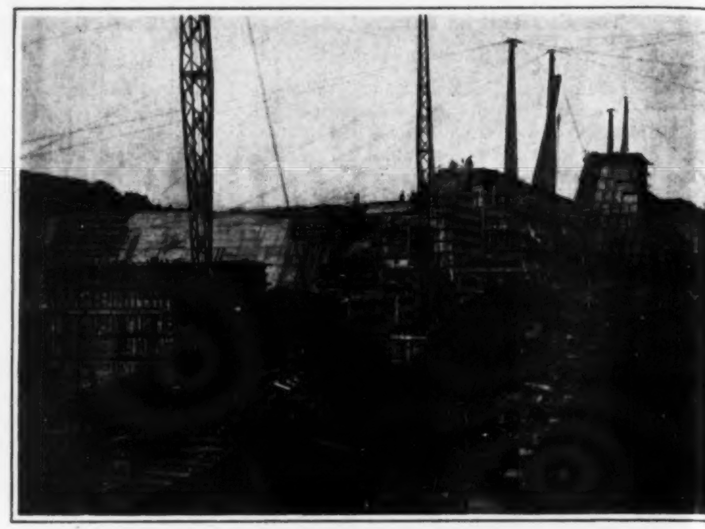


Fig. 2.—Looking upstream from bank side of the lower lock site. All lower lock footings are in, without fifty per cent of superstructure. About 190,800 cubic yards of concrete have thus far been placed in the dam. (Photo taken December 20th, 1913.)

The Black Warrior River Lock and Dam

Cheapness of Transportation Secured from a Center of Production to Tidewater

By Harry Chapin Plummer

As work progresses upon the Black Warrior River Lock and Dam No. 17, above the city of Tuscaloosa, in Alabama, and that gigantic engineering structure begins to assume definite form and to reveal its even greater lift dimensions than the Gatun and Miraflores locks of Panama, the Southland's imperial dream of a navigable waterway "from Birmingham to the Sea," nears its realization. Lock and Dam No. 17 is the chief accomplishment in what is known as the "Tombigbee, Warrior and Black Warrior River improvement," by which a water avenue is to be opened up for the immense tonnage of coal and ore, and iron and steel products, originating about the Alabama industrial center.

Almost $9,000,000 has been appropriated by the United States Government toward the development of navigation on the Warrior River system. The last River and Harbor Act, passed March 4th, 1913, set aside $1,338,500 for that purpose and secured to the Government the full title and riparian rights in the vicinity. The sponsors at Washington of the Warrior River improvement, headed by Capt. Richmond Pearson Hobson, Representative from the Sixth Alabama District, advocate the provision of sites for power-plants "in all cases where the development of large power is involved in improvements for navigation."

With the completion, next August, of Lock and Dam No. 17, slack water navigation will be extended to within a few miles of Birmingham, and plans now before the United States Engineers contemplate the accomplishment of a channel directly into the city. The present improvement embraces the Mulberry and Locust Forks, both tributaries of the Black Warrior River, which form the nearest natural water approach to Birmingham.

The total length of the Warrior River system which is subject to improvement, and extending from the mouth of the Mobile River, at the Gulf, to within sight of Birmingham, is approximately 511 miles. It is in the section of this proposed channel lying between the junction of the Warrior River with the Black Warrior River, at Tuscaloosa, and the confluence of the Mulberry and Locust Forks, a distance of only 46½ miles, that Lock and Dam No. 17 is located, at a point known as Squaw Shoals.

Below the Locust and Mulberry Forks, there are 18 locks on the Warrior River system, and of these, of course, Lock and Dam No. 17 represents the most signal engineering achievement, since it will have a 63-foot lift, in two flights, or steps, of 31.5 feet each. There are few lifts in the world exceeding that of Warrior River Lock and Dam No. 17. The greatest lift is that of the Masurisch Lock on the Dergefelde River, in East Prussia, which has a single lift of 65 feet. Next in order come the Hale Bar Lock, on the Tennessee River, and the Keokuk Dam Lock, on the Mississippi River, with lifts of 41 and 40 feet, respectively. The tandem lock at Big Eddy, on the Columbia River, has a total lift of 20 feet. Panama's mightiest lock, Gatun, has a total lift of 85 feet, divided into three steps of 28⅓ feet each, while Miraflores lift totals 55 feet, in two steps of 27½ feet each.

The construction of Lock No. 17 was commenced under a contract dated September 20th, 1910, providing for a 21-foot lift, but after considerable preliminary work had been done by the contractor, the height of the lift to be provided at this dam was changed to 63 feet, by action of the Secretary of War, under Act of Congress approved August 22nd, 1911. A supplementary agreement was made with the contractor, under date of January 12th, 1912, for the construction of a 63-foot dam, with two locks and tender's house.

Construction work has proceeded under the direction of the United States Engineer Office at Mobile, Ala., Lieut. Colonel C. Keller commanding, with G. K. Little, assistant engineer, in charge at Tuscaloosa. The contract work at Lock and Dam No. 17 is now about 57 per cent completed, the excavation for approaches, foundations for lock, guard and breakwater walls, and about 60 per cent of the dam site having been accomplished. Excavation for about 40 per cent of the dam site, the entire abutment foundation and back filling of all walls is yet to be done. Thus far, 88,000 cubic yards of rock and 18,000 cubic yards of earth have been excavated, leaving about 53,600 cubic yards of rock, and, including back fill, about 145,600 cubic yards of earth to be excavated. All the wall faces have been channeled in rock cuts.

Of the concrete structure, the upper lock walls, part of which, from footings to coping, are 101 feet high, are complete with miter walls. All lower lock footings are in with about 50 per cent of superstructure. The four upper guide walls are finished, and about 500 linear feet of the dam has been completed. Up to date, approximately 190,800 out of 295,800 cubic yards of concrete have been placed. The contractor is placing concrete

Fig. 3.—A view of the lock side from hill, showing the upper lock walls, part of which, from footings to coping, are 101 feet high, now completed, with miter walls. The four upper guide walls are finished and about 500 linear feet of the dam is complete.

Fig. 4.—Lock No. 17, with part of dam. A general view from cofferdam. This lock, when completed, will accomplish a lift of 63 feet, in two flights, or steps, of 31.5 feet each. Three pairs of steel mitering gates are now under construction. (December 20th, 1913.)

at the rate, approximately, of 20,000 cubic yards per month, working one eight-hour shift.

There have been installed thus far 230,000 pounds of valves and special irons, including cylindrical valves, line hooks, equalizing pipe and valves, sluice valves and gears in the dam, reinforcing steel, electric transmission conduits, etc., but no operating machinery for gates and cylindrical valves has been set up. The three pairs of steel mitering gates are now under construction at the United States shops at Tuscaloosa, Ala., and will be erected by hired labor before the locks are turned over to the Government.

War Department officials seldom indulge in prophecy and the following observation upon the Warrior River improvement contained in the last Report of the Chief of Engineers, U. S. A., is, therefore, worthy of note:

"The work of lock and dam construction has thus far had a marked effect on traffic. What effect the all-year-round maintenance of navigation will have when obtained cannot be definitely stated until the project is completed, but indications are that it will cause great reduction in freight rates and develop an extended traffic between the coal fields of western Alabama and the Gulf of Mexico."

Yet more glowing is Representative Hobson's prediction for his native commonwealth, as may be determined by the canalization of the rivers:

"This region stands without rival anywhere in the world, while the great raw materials are on the spot. Coal and water-power are located in the cotton fields and alongside the iron mine, a combination which has never been approximated, and apparently never can be approximated, anywhere else. Cheap water transportation for ore on the Great Lakes can never overcome Alabama's inherent advantage. Both in the assembling of raw materials and in the supplying of power for their manufacture—the two factors in cheapness of production—the waterway region of Alabama stands supreme. I do not think that anyone who looks into the question will seriously challenge my statement that the conditions for ultimate cheapness of production for the great world staples place Alabama in a class by herself and unparalleled anywhere in the world. The other great factor in winning the markets of the whole world will be cheapness of transportation from the centers of production to tidewater and from tidewater to the markets of the world. In the fierce competition that will result, the inherent advantages of water transportation over land transportation will be a determining factor; water transportation uses a level, almost frictionless fluid of great weight, and does not involve the comparatively heavy friction of solids on solids. For heavy transportation, therefore, water must always offer an inherent advantage. The question of transportation from tidewater to the markets of the world gives a great advantage to the Alabama section. With the final opening of the Panama Canal, the center of distribution of world staples will soon shift from the English Channel to the Caribbean Sea. Alabama thus will have tidewater outlets closer to the center of distribution than any other competitive center of production. Her advantage, however, will come in the cheapness of transportation from her centers of production to tidewater. There is no comparison with those distant inland centers which at present supply the home market. The Alabama centers are located close to tidewater, to begin with, and will have the benefit of water transportation for even the short distance that intervenes, in that the Alabama, Tombigbee and Warrior rivers will insure slack-water navigation from the centers of production to tidewater."

A Canadian Suspension Bridge

By Frank C. Perkins

THE accompanying illustration shows the construction of a picturesque suspension bridge recently erected near Hazelton, Western Canada, by wire rope manufacturers and engineers of Wakefield, England. The bridge is of the stiffened suspension type provided with stiffening girders which minimize undulations of the platforms due to the passage of concentrated loads. These girders also serve the purpose of side railings. The span between the centers of the tower saddles is 451 feet and the bridge platform is 250 feet above the river. The main cables are 2 7/16 inches in diameter and are of locked coil construction. They are made of improved plough steel and each has a tensile strength of over 300 tons.

The suspension rods, spaced 4 feet apart, are attached by being secured to heavy steel cross beams diagonally braced for wind pressure. At each end of the bridge are wood towers having a total height of 68 feet and reaching 47 feet above the platform level. The wood decking or platform consists of longitudinal joists bolted to the steel work and covered with 3-inch floor boards.

The bridge has been constructed for vehicular and foot-passenger traffic, and is now the means whereby a large tract of country, hundreds of square miles in extent, which hitherto had been practically isolated, has been opened up to regular communication and industry.

The site of the bridge was in the direct route during the great gold rush to Klondike, the adjacent township of Hazelton being the last of the old Hudson Bay Company's trading posts at which the hurrying gold seekers were able to refit and replenish their stores before taking up the last stage of the trail.

It will be seen that beneath the suspension bridge there is another novel structure. This is a bridge constructed by Indian trappers to enable them to exploit the hunting grounds on both sides of the river. It is the third bridge of its kind built by the Indians, the two previously erected having been washed away by the turbulent waters of the Bulkley. As an example of native ingenuity the bridge is extremely interesting, especially as there was not a single nail employed in building it, wooden pegs being used to fasten the beams and spars together.

The Reddening of Leaves

PROF. GASTON BONNIER has presented to the Academy of Sciences a new study of M. Raoul Combes, concerning the crystallizable substances that are found in leaves. One of these substances of a yellow color is found in green leaves; it is this substance which produces the reddening of leaves in autumn. M. Combes, who had obtained outside the organism the synthesis of the red substance, by starting from the yellow substance by reduction, has just obtained the inverse, that is to say, the synthetic production of the yellow substance, by starting from the red substance, by oxidation. Thus the general question, the answer to which has been so long sought after in vegetable physiology, has at last been solved. Besides its general importance in the life of plants it is easily understood that this solution may be susceptible of practicable applications, notably in what concerns the different varieties of vines.—*Chemical News.*

A Substitute for Matches.—It sometimes happens that the automobilist is caught on the road after dark without matches with which to light his lamps. An easy way out of the difficulty is to make use of the ignition system for supplying a light. First make a torch by twisting a small bunch of waste around a piece of wire and wet with a few drops of gasoline. Then remove one of the high-tension wires from its spark plug, throw on the battery switch, and turn the engine over until the spark comes to this wire. The waste is then ignited with a spark drawn from between the cylinder-head and the end of the wire, taking care to hold the wire by its insulated portion. In getting a light by this method care should be taken to use only a small quantity of gasoline, as otherwise there is danger of having too much of a flash of fire when the spark strikes the gasoline-soaked waste.

Stiffened suspension type of bridge over the Bulkley River, near Hazleton, Western Canada. Bridge platform 250 feet above the water. The rustic structure beneath was erected by Indian trappers for hunting purposes.

A Canadian suspension bridge.

Greek Animal Drawings

The Studies of Morin-Jean

By Alfred Emerson, Ph.D., Chicago Art Institute

The clearing of a pictured cavern in Perigord recently confirmed what prehistoric carvings on reindeer horn found in the glacial age caverns of Dordogne established long ago—namely, the capacity of quaternary men to engrave the outlines of a mammoth, a reindeer or a buffalo in action on bone or stone surfaces. The horse, too, figures repeatedly in the subterranean art galleries. They can reasonably be called such, since the pictures in them are many, and were not only engraved but painted.

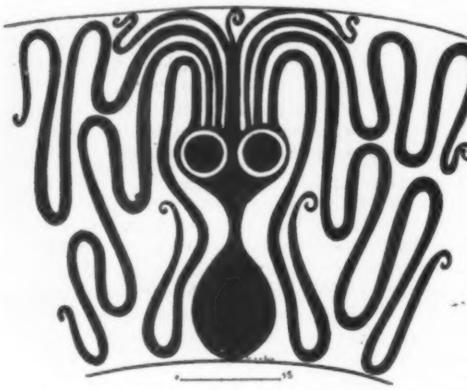


Fig. 1.—Cuttlefish. From a Mycenian winehorn.

If many later and some contemporary delineations of animal life appear less true to nature than the quaternary examples, it was most likely because the shorthand devices of the symbolist carried an element of unreality into the rendering of form. Religion and ritual, heraldry and decoration easily abandoned realistic portrayals for conventional. A Thlinkit weaver or carver scatters fish eyes and bear claws all over his blanket or his totem pole. Empires and republics adorn iron letter boxes with spead eagles of fantastically regular silhouette and plumage. No live bird wears the strange crowns, halos, chains and escutcheons they sport; no live bird ever used the properties they brandish in their talons. This beast has one body and two heads; another, perhaps, will have one head and two bodies. We are very close here to the savage's and the child's fondness for drawing all he knows, regardless of his model's actual aspect. Both will depict four sides of a house, or both sides of an animal, in a single drawing. Both will combine exterior and interior scenes on the same panel, let alone a dozen episodes of the same story.

Primitive draftsmanship puts another trammel of reality behind it by creating hybrid forms. In this particular the heritage of the Chaldeans and Hittites is with us yet. Their two-headed eagle became the imperial eagle of Byzantium, and later of several other east European and central European kingdoms and empires. Their winged lion and bull have attached themselves to St. Mark and St. Luke. Their griffons have found a station in the arms of Austria. Their water woman is the badge of Nuremberg. Their winged genii spread their rainbow pinions above our altars.

Classical Greek art inherited the fine decorative motives of the near east. It never threw this Oriental capital away, wide as the genius of its own artists soon opened the paths of truth to nature and realism. Nowhere shall we find the contrast between the conservative art of the temple and the progressive art of the racecourse and parade ground more luminously illustrated than we do in the case of Phidias, who finished the gold and ivory image of the virgin goddess in the cella of the Parthenon in the year 438 B. C., and of the younger Athenian sculptors who did the marble decorations on the exterior of the same Greek temple on the citadel rock of Athens. The older master came not to destroy, but to fulfil. It was a far cry from the serpent goddess of prehistoric Crete to his forty-foot Athena. Yet the primeval serpent emblem writhed and wriggled at her knee, at her girdle, on her breast, along the rims of her ægis, helped steady her bamboo lance, and added terror to her shield. Plumed knight never rode into battle with a livelier heraldic menagerie displayed on his gear.

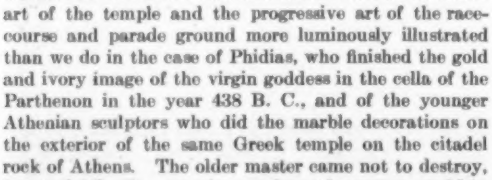


Fig. 4.—Lion and fawn. Rhodian, about 650 B. C.

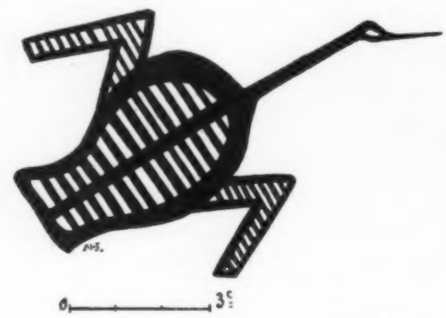


Fig. 2.—Flying bird. From an eighth century Athenian jar.

Two winged horses and a bronze sphinx supported her triple crest; two griffons ramped on the upturned cheekpieces of her golden helmet, behind a serried rank of other embattled quadrupeds that crowned her lifted vizor; combats of men and centaurs enlivened the very soles of her thick Etruscan sandals; a winged Victory perched upon her outstretched hand. The same master's temple statue of Zeus at Olympia had the veil of Jehovah's temple at Jerusalem for its curtain, by the gift of King Antiochus. The unreal flora and fauna of the east were marshaled arow on its rich Oriental fabric, in the spirit of the sixth century Corinthian decorators.

The splendid artistry of the extant Parthenon marbles has become a commonplace. I wish only to indicate their author's departure, here, from the symbolic devices which came close to overloading the colossal image within the temple, and in lesser measure the seated figure of Zeus at Olympia, which the master constructed after his acquittal of graft and irreligion in the courts of his native city. Puchstein's proclamation of the other men's un-Phidian spirit is but another way of saying that Greek sculpture shook off every vestige of the earlier Asiatic schooling which impeded progress, the day it conceived those immortal marble offerings to the lady of the Acropolis—"*pillar of gold, tower of ivory, star of the morning.*"

M. Morin-Jean, the author of *Le dessin des animaux en Grèce*, wields the brush and the pen with equal facility. His understudies Edmond Pottier at the French educational service's wonderful *Ecole du Louvre* (the like of which we shall never see in this country until we can match the *Louvre* itself) gave him the happy idea of reviewing the manners in which the ceramic painters of Hellas and its colonies delineated animals. Omitting the more strictly prehistoric periods of the Cretan or Ægean and of the legendary Mycenian civilizations, the French critic's three hundred drawings acquaint his readers with documents culled from painted, engraved and molded Greek, Italiote and Etruscan vases of fourteen successive and co-existent styles from the geometric decorations of 800 B. C. and onwards to the decline of the art in southern Italy about 300 B. C. Nearly all his pictures were copied from originals in Paris public collections without neglecting other north-of-France galleries. For his rule was to exclude all second-hand material, even photographs. Once in a while, of course, there was a good reason to forget it. Even so, Morin-Jean has covered the whole subject of antique animal painting better than anybody ever undertook to. One hardly knows whether to admire the more the skill of his pencil or the precision with which his commentary defines the characters and the local prevalences of the eastern and western Greek schools. Shoals and shallows menace the keel of the navigator on this sea at every tack.

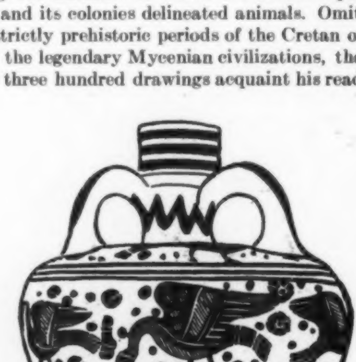


Fig. 5.—Corinthian Amphora with feeding swans. About 600 B. C.

Fig. 3.—Flying dove. Boeotean. About 700 B. C.

Homer's princes and princesses patronized the Mycenian kilns, whose owners loved to paint the creatures of the Grecian brine on their crocks—not shells, crustaceans and fish proper so often, indeed, as medusas, cuttlefish and similar mollusks. They could thus indulge their fondness for curvilinear and spiral lines to the full; it was a method of design which their Egyptian and Cretan predecessors in the applied arts had spent centuries in developing. The successors of the Mycenian potters were far from equalling their elegance in drawing, although their vessels themselves were more skilfully thrown on the wheel, and better fired to a smoother finish. With the transition from the bronze age to the iron, toward 1,000 B. C., came the overthrow of the feudal and lordly Mycenian kingdoms of southern Greece by the Dorian highlanders. This revolution affected south European civilization very much as the triumph of Protestantism affected northern Europe twenty-five centuries later; for we see Greek designers of the early iron age content to use an angular and rectilinear system of drawings such as American red men might have evolved, regardless of the superior creations of their Achæan predecessors. The painter of the migratory fowl we re-engrave was nevertheless no stranger to bird life. He has seen geese and cranes stretch their necks rigid in flight. His Boeotian colleague will prove to us that even this multilinear mode of recording animal forms and actions achieved a degree of realism.

The seventh century potters of Rhodes, an easterly Greek island occupied by Dorian settlers from peninsular Greece, painted with a brown-black glaze on buff clay. They draw their animal subjects in alternations of silhouette with outline, and retouch them with engraved details. The wealth of their repertory is astonishing. These chimeras, griffons and sphinxes, hounds, lions and panthers, ruminants, wild boars and fish will continue to precede and face one another on the storied zones of

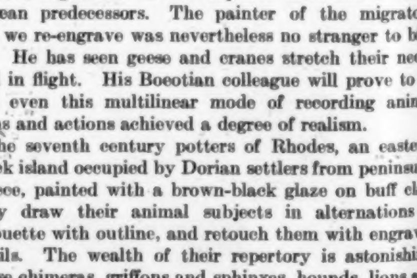


Fig. 6.—Corinthian boar. From a Corinthian oilflask.

the Corinthian potters of the homeland, much as they do on the Rhodian plates and ewers. Both schools detach these creatures of the field, forest and flood against drop-scene backgrounds star-studded with weeds and flowers. But the Isthmian decorators are inclined to exchange the buff reserves of the Rhodian style for patches of purple overlay on the black glaze figures, and they make more of their incised details. Their decorative quadrupeds have commonly shed their Asiatic pinions. They are real beasts. What could be bristlier, hammier and altogether swinier, for example, than this delectable black hog from a Corinthian oil flask? The reign of this style extended from about 750 to about 550 B. C.

The Corinthian manufacturers were merchants more

Fig. 7.—Osprey on a hare. From a Ceretan water pitcher. About 550 B. C.

than artists. It is hardly for us, who find all hand work too expensive, to condemn them. They filled Hellas and Italy with their decorated earthenware jars and pitchers and winecups and toilet boxes. Small wonder if many of these articles, recovered from Isthmian, Boeotian and Etruscan cemeteries, show laxity of execution. But Athens itself accepted the Corinthian mode of presenting story-subjects. The finest of all early Greek vases is the famous Vaso François at Florence, which Zei's masterly handling has lately brought to an even more perfect state of repair than it enjoyed before a crazy museum guard smashed it to bits twelve years ago. The Athenian painter who decorated this wine-bucket, or krater, for some king of Clusium 550 B. C., distributed his ten figure subjects from Greek myth and epic story in six stripes of picture work rising one above the other like the colored stripes on an Oriental curtain. In short, the habits of the textile arts still influenced the Greek pottery decorators of that period as vitally as the habits of the metal-worker's craft governed the form and build of earthen vessels.

As against the 281 figures of gods and goddesses, men and women, birds, beasts and monsters that compose the six frieze-stripes of the François vase, the later advance of the art at Athens abandoned multiplex pictures for simpler subjects; when following it we feel as if we ourselves were passing from a collection of embroideries to one of actual pictures. The fine arts were beginning to repay the debt which they owed to the applied arts at their origin. The progress which the ceramic industry had made in Oonia, at Corinth and at Chalcis on the Euboean Sound was grafted upon the antique, local tradition of the potters' quarter at Athens with a wonderful ingenuity by the black-figured vase painters of Attica foreshadows their guild's equal success in assimilating the superior draftsmanship and composition of the great mural and panel painters of fifth century Hellas, after black figures on red grounds were abandoned for red pictures on black vases. We shall consequently find the freehand graces of the Rhodian school happily blended with the quadricolor system of Corinth, and eventually surpassed altogether in the brilliant zoologies of sixth and fifth century Athenian jars and winecups and oil flasks, until Athens stands forth the unrivaled art capital of the whole Grecian world. The Perikleian republic was queen no less in the applied arts than in the fine, no less in these than in poetry and eloquence.

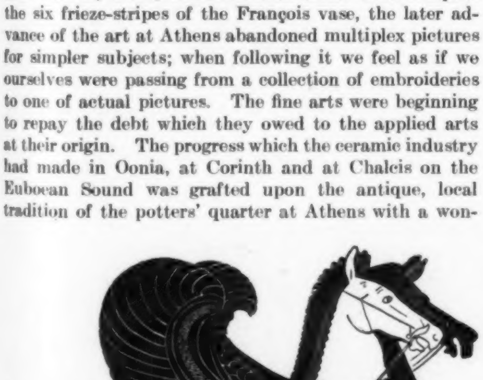


Fig. 11.—The winged racers of Neptune. Athens pitcher. Toward 525 B. C.

Fig. 8.—Head and claw of Osprey. From nature.

The culmination of her unrivaled sea power coincided with a culmination of her industrial lead.

No doubt the manufacturers of Athens lost some of the primeval Greek freshness in the course of outstripping their industrial rivals. But this was largely a question of population. The encroachments of tillage on the forest lands of Attica robbed her sportmanly squires of their older joy in the chase. Diana herself saw gingerbread stags burned on her rustic altars instead of real venison. Deer and wild boars give way to gamecocks and race horses on Attic earthenware, because cockfights and horse racers engaged the attention which the rural gentry had once given to hunting.

In the meantime, the Ionian order of epic and dramatic poetry, the Ionic order in architecture, and Ionian styles of sculpture and painting took the Greek world captive. Homer, Phidias and Apelles were all of the Ionian race. Italy fell under the same spell; populous Greek colonies occupied the southernmost half of that sister peninsula. We do not know whence the inhabitants of Etruscan Caere near Rome procured the Greek vessels that are found there, but we do perceive them to be of Ionian fabric. The Etruscans themselves learned the trick of imitating Ionian bronzes and clay products. One of our illustrations shows how faithful to the details of nature the painters of those export goods were in their ornithology. Another reveals them a trifle at sea about African carnivora. A third shows them familiar with the beaver, a creature that was scarcely known in peninsular Greece at all. The painter of the second had probably seen a lion, but no lioness, since he gives his female the big head and the shaggy mane of the male animal. He negotiates difficult points like its cat paws or its orbital cavities deftly enough, and has equipped its jaw rather oddly with the right number of molars. Not one antique drawing of this beast in a thousand is correct in this particular.

In the days when Athens endured a government of princes, like contemporary Rome, the decorators of the motherland abandoned the old buff ground tone for an orange slip or glaze. This change must have occurred about 540 B. C. Their principal pigment remained a glossy black oxide of iron color, which they embellished with engraved linear details and with white and purple overlays like the master of the François krater. Light and shade, rotundity and oblique aspects they refrained from attempting. It is doubtful whether even the mural painters of the period had any inkling of these meretricious devices. The sea-god's miraculous steeds retain the old, Asiatic symbol in our next picture, together with an Asiatic way of drawing it. This painter could draw far better than this when he chose to. Observe the masterly lines defining the white horse's thorax, leg muscles and articulations, or its tidy feet. He knows very well, too, why he gives the god a Jersey team. We shall detect him committing another progressive breakaway. He considers the orthodox, traditional way of doing a horse's eye the correct one to use when your animal is a black one; not so, however, when its coat is light and your drawing is done with a brush. The shrewd old chap understood even to the contrasted optical sizes of equal white and dark surfaces. It remained for the masters of the fifth century red-figured style to achieve the correct rendering of a human or animal eye in front and side view; for art is indefinite.

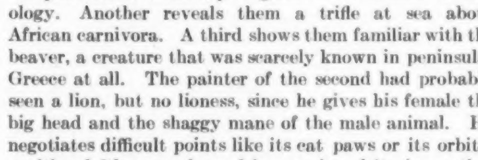


Fig. 12.—The horse's eye in Greek vase painting. 1, Corinthian; 2, Ionic at Corinth; 3, Caere; 4 to 10, black figured Athenian; 11 and 12, red figured Athenian; 13, late style of south Italy.

Morin-Jean accords small attention to the developed, red-figured art of the Attic potteries. We perceive by this that a completed evolution ceases to hold his interest. Many present-day zoologists have no patience with mammals for the same reason. Otherwise, one would like to bespeak a second ceramic picture-book to cover this field, besides the one he promises to cover, the pre-history of Greek animal drawing after his projected visits to Athens and Crete, where alone it is well represented.

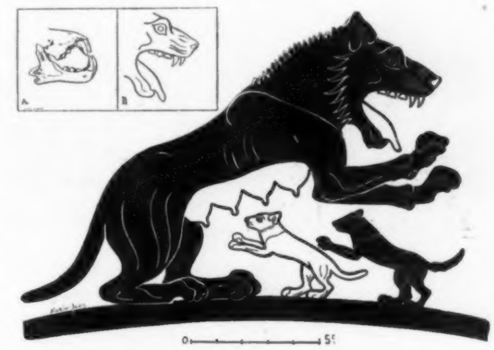


Fig. 9.—Lioness and cubs. From a Cretan water-pitcher. Fig. 10.—Above the lioness, outline of skeleton (A) and opened jaws (B).

The art of the antique potter and Greek animal drawing enjoyed a strange Indian Summer in southern Italy after the industry ceased to produce anything new in Greece proper. It is not to the Apulian and Campanian kiln-masters of the fourth and third centuries that one repairs for a fine conception of the human figure. Indeed, most of their work betrays culpable carelessness. One is all the more surprised at the extraordinary talent they possess for rendering every species of fish and mollusk known to their southern coasts, from the spiny perch and the repulsive gurnard to the ray and torpedo, the lamprey and the horrid tentacles of the cuttlefish. They invented a new technique for these nature studies. Swift strokes and washes of brownish-black pigment on a clay paste with a rose-colored glaze were followed up with heavy but equally swift white streaks and blobs, overlying one or both under tones indifferently. Pictorial ichthyology has advanced from a limited capacity to render species and structure only to a masterly portrayal of personality and action. And this personality does not wilfully transcend the personality of a fish. Thus, antique art was unsentimental to the last. It does not conjure expressions meet for men, women and children onto the faces of its beasts and birds. For that matter it accords the higher animals less personality than they really have. All its horses are speedy and gallant; all grown lions at least are strong and fierce. No animal betrays poor stock, or malnutrition, or lameness or suffering or old age. A sensitive collector of antique pottery will often bewail the abrasion of a painted animal's face or leg, but he will scarcely be prompted to deplore its hard lot. A modern chord, unknown to antiquity, has been struck when we feel sorry to see Thomas Bewick's British farm horses stand so disconsolate in the chill rain.

Exchanging Atlantic and Pacific Fishing Industries.—The United States Bureau of Fisheries has undertaken the task of transferring several carloads of live lobsters annually from the coast of Maine across the continent for deposit at points in Puget Sound, in the hope of establishing this valuable crustacean on the Pacific coast. A fair exchange is no robbery; the Bureau is also planning to transport eggs of the humpback salmon from the Pacific coast to the New England hatcheries, and to place the resultant fry in some of the Maine rivers.

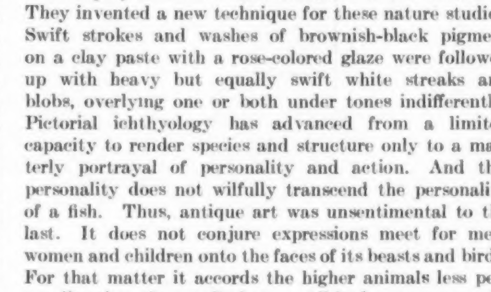
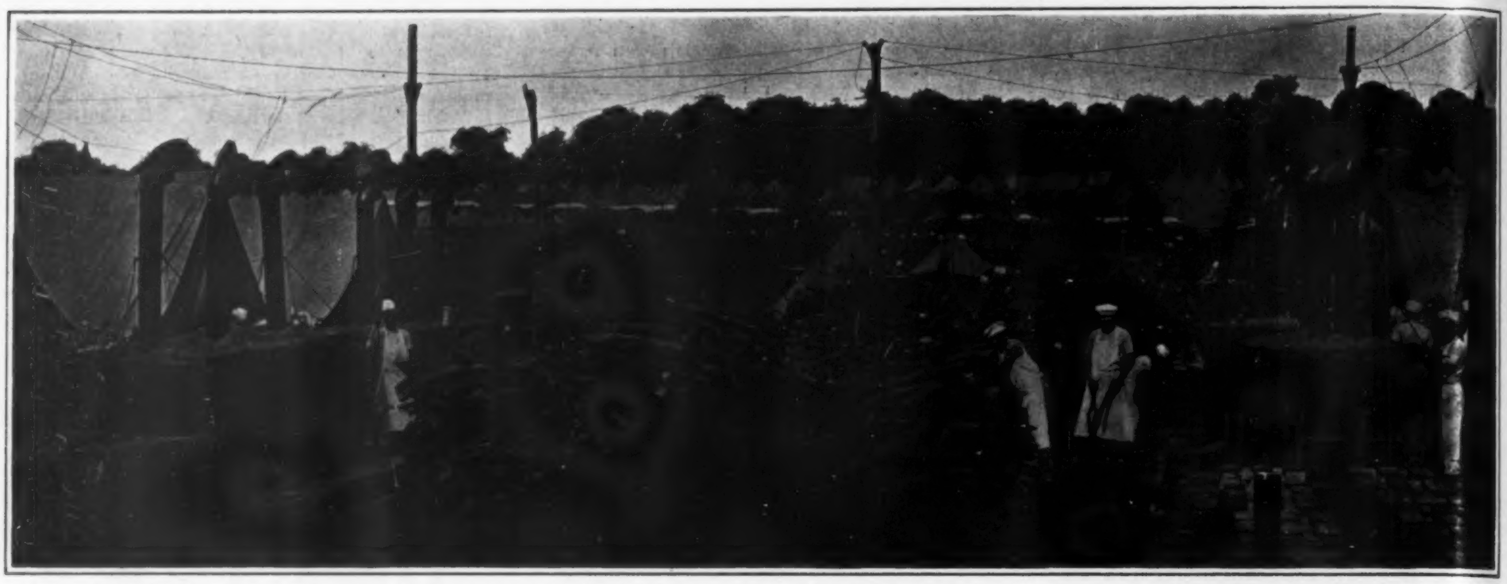


Fig. 13.—A Wrass. From an Apulean fish plate.



General view of an army encampment, showing the field kitchen, including ovens which will cook for a brigade of men. In the foreground the wood is shown which is used for fuel.

What Our Military Cooking Schools Mean to the Soldier

In Future Wars the Bullet, not Ill-Prepared Food, Will Be the Cause of Loss of Life

By Day Allen Willey

THE history of the Civil War proves that the soldier must have nourishing and strengthening rations, if he is to be courageous on the battlefield. After General McClellan's army had been defeated and forced out of the State of Virginia by the Confederate troops, the War Department discovered the reason. It was the physical condition of the soldiers. Their rations were poor in quality and small in quantity. The reports of the army medical officers, and its commander, now in the files of the war records state more men died from diseases caused by want of nourishment than were struck down by the bullet and the shell.

The Civil War was an object lesson in the vital necessity of making our fighting men healthy and vigorous by rations which would build up the body, and give the man behind the gun the nerve and endurance that make the man in the ranks a true soldier. To-day no commissary service abroad excels our system of buying, and the distribution of food for rations, testing every viand for purity, and educating the private how to prepare the meal in the barracks, the encampment, on the march, and even on the battlefield.

The War Department has aided this plan for real soldier-making. No one knows better than the "official staff" and its chief, General Leonard Wood, as to the need of the company, regiment and brigade having enough trained cooks and enough supplies to give three healthful meals a day to every man in uniform.

At the large army posts are schools where men selected from the different commands stationed throughout the country, take a course of instruction in using the stationary equipment in army barracks, the movable cooking outfits that will supply a regiment, yet can be carried on the march, strapped to the back of an army mule. They are taught to think of different bills of fare, so as to vary dishes and not provide the same rations day after day. They become expert in detecting adulterated or spoiled flour, decayed meat and vegetables, impure milk and other causes of ill to their comrades, by tests that they learn to make in the laboratory with which each school is provided.

In the central part of the country is the school at Fort Leavenworth, Kan. The commands of the Pacific Coast are served by the school at Presidio, San Francisco, while the school at the army barracks at Washington trains cooks for the commands of the East. Each school has a director who is an army officer, and the same system of teaching, prescribed by the Commissary Department, is carried out at each of the three institutions.

The whole idea is to furnish each man in the ranks wholesome rations at the smallest expense. Such is the system of buying good food in large quantities that it is an actual fact that the average cost of the raw material, and the preparing of it for the table, is a fraction less than 24 cents for a meal for each man, and this in spite of the much higher food prices as compared with 1895, when the cooking schools were opened. The mess sergeants, cooks and bakers trained that year furnished rations at an average cost of but 12 cents. To show the kinds of food and beverages that are required to be served, the soldier eats such viands as fresh beef, bacon flour, soup, beans, butter, rice, cornmeal, potatoes, onions prunes, jam, peaches, apples, coffee, sugar, evaporated milk, pickles, spices, lard.

To tell clearly just how they train the soldier to know what is good for his fellows, and prepare it in a palatable way, the routine of the cooking school of the army barracks at Washington may be cited. The director, Capt. Lambert Barton, and his assistants are skilled in food testing, as well as every method used in preparing the rations.

Entering the model kitchen, one notes that the military pupils kneading the dough, slicing bacon, operating the electric cutter, which also cuts up the potatoes, are all uniformed in white. They look like the food-makers in the hotels. At the end of the kitchen are two large ovens.

The kitchen of the school is an interesting place, and is about ten feet square, with a high roof, the whole covering most of the one-story building which has been built for it. The walls are of white tiles, and the floor is cement. There are long tables running through the center, and near them a great dough trough of iron. At the back are two huge bake ovens, one of which is set in the floor and is faced with white tiles, while the other is made of iron coated with porcelain, and is in parts, so that it can be taken down and moved at a moment's notice. These ovens are object lessons to show modern methods of cuisine.

The soldiers are shown how to take apart the portable oven and to put it together, and upon graduation, any

A canvass storage house for army bread.

Mixing the dough for army bread.

one of them could go with it to the Philippines or anywhere else, and operate an army bakery. This oven is 10 feet wide and about 15 feet long, and stands higher than a man's head. It will prepare 420 loaves at once, and can bake thousands of loaves in a day. The stationary outfit is also equipped for baking and boiling, has a pan and broiler holder for its purposes, and its capacity is such that it will cook food enough for a brigade.

In the storehouse at the school, hundreds of these ovens are seen, one of which will do the cooking for three regiments, and are stacked in piles. Made of sheet iron covered with tar to protect them in the open, the sides and top can be assembled in ten minutes by two men, ready for use. When in the open, the top is usually covered with clay and gravel. This mixture keeps the heat from bending the metal top and confines it to the oven. These are what might be termed adjustable ovens and include several types. On the draw plate oven, the heat is carried into the chamber by piping, which is attached to the movable sheet iron shelves that can be taken out by the rollers on which they rest. They perform what is called continuous cooking and can be used for preparing rations every hour of the night and day, for a week or more if necessary.

Another type of the "knock-down" field oven is intermittent—not continuous—in cooking. In this, it is necessary to draw the fire before each baking, if baking is done in the chamber in which the fire is built, as in the common brick oven and the semi-cylindrical type of the knock-down field oven; or in other types, to let the fire die down at some time while each successive batch is being baked, thus requiring a certain lapse of time between the bakings. Permanent ovens are generally built of solid brick and weigh as much as 50 tons. Such ovens are installed at most post bakeries, also the common brick oven.

Where the army may be in winter quarters, or encamped for several months, much of the food is prepared by what is termed a portable oven, which can be taken down and moved. The term is applied to the Middleby, that can be taken down tile by tile and moved, as well as to the light knock-down field ovens that may be taken down and prepared for wagon transportation or set up in a few minutes. When soldiers leave camp, the ovens are left behind and sometimes are used by the country people for smoking hams or bacon.

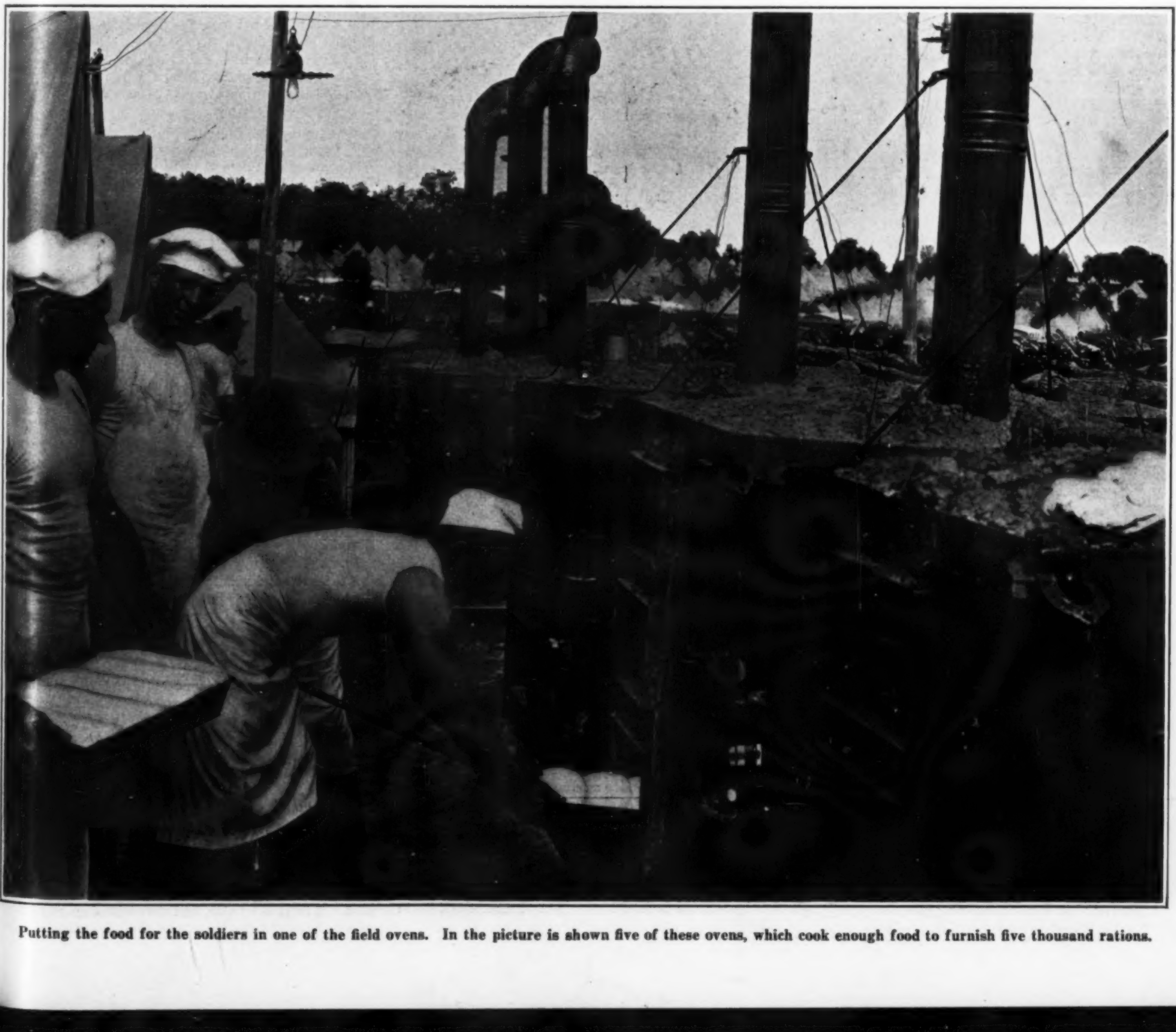
The term "knock-down" applies to the oven which is carried in sections on the march in army wagons with all the culinary utensils. These are termed portable ovens, and are of several designs. One of these which performs every kind of cooking is formed of glazed tiles in generously set form, the walls of the oven side being a framework made of crowbars which support trays of sheet steel, also drawn out and in on rollers. The heat for roasting, boiling or whatever the process may be, comes from wood fires. The fires are placed in the open and are usually made by excavating a hole two or three feet deep in the earth, covering the bottom with small stones on which are piled small pieces for kindling which ignite the firewood above them. As the field oven has not a bottom, and its sides and rear frames extend upward, the heat rises directly to the trays and other cooking receptacles.

These military food creators are taught that an oven that has never been fired should be heated by a slow continuous fire for four or five days, with all the dampers open, to allow the moisture from the materials of which it is constructed to escape, then fire heavy enough for two days to attain a baking temperature. If not required for immediate use it would be advisable to let the oven stand with all drafts open from two to four weeks before starting the first fire. Brick ovens, if cold, take two to four days to heat up before they will do good work, and even then the chances are that they will not have become fairly heated throughout for baking top and bottom equally well. For the daily firing, when the oven is regularly used, the fire is started at least two hours before baking, leaving the draft dampers open. All ovens possess certain peculiarities and new bakers cannot expect to turn out loaves of uniformly good quality until they have become accustomed to the particular oven in use. In many double ovens, that part near the common partition becomes hotter than other parts—likewise the parts of the oven farthest from the door. Hence it is that pans of bread first run into the oven may go to the hottest parts, and from necessity may be the last to be withdrawn. If such an oven is used to its fullest capacity, some of the loaves are apt to be highly browned or even burned before others are ready to be withdrawn, as shifting under these circumstances is done with difficulty. Care must be taken to keep pans away from the common partition of such an oven and to fill the cooler parts first.

As to the portable ovens for baking bread, biscuits and other bread stuffs, the proper equipment for field bakeries is based upon the requirements of a regiment of infantry, with a view to combining two or more regimental bakery equipments to form a bakery for a brigade or division. Detached battalions should draw bread from the nearest bakery. A field bakery should be established and operated in connection with every post bakery, in order that bakers may become thoroughly familiar with the field equipment and confident of success when required to use the same.

In this kind of an oven, a jacket of earth forms an essential part, and the baking properties depend largely upon the heat absorbing and radiating capacity of the materials used. If the soil is sandy, the jacket of earth may be dried out in a few hours and good results obtained, but if the soil is of clay and permeated with moisture, it will take much longer to get satisfactory results; especially is it difficult to get a good browning on the bottom of the loaves until the oven has been used for several days. The ovens are called "straight fire" or "draw fire" for the reason that the fire is built in the oven chamber, and is drawn when the oven has been sufficiently heated for baking. The amount of fuel to be used can be so regulated by experience that there will be few coals remaining to be withdrawn when the oven is ready for use. The fire being withdrawn, the oven is closed up tightly for an hour or more to equalize the temperature throughout. It is then ready to receive the loaves, and care should be exercised to have it in readiness when they are sufficiently proved.

The simplest type of cooker, and one for use by the squad of soldiers who camp out in one tent, is an oval shape cone of sheet iron melted together at the edges, the top ending in a small opening. The heat is furnished on a stone-lined bottom, and from this little oven, placed



Putting the food for the soldiers in one of the field ovens. In the picture is shown five of these ovens, which cook enough food to furnish five thousand rations.

outside the tent, heat is carried by a length of stove pipe, while the mess private is cooking the rations.

The description of the ovens is one feature that soldier-cooks have to learn at these army cooking schools. Another is, the rations must be prepared for each meal in camp, on the march or in garrison. Assuming that field rations for ten days have been supplied, the bills of fare cited are considered as appropriate, and, in all respects, covered by the articles provided. Ten days' rations are as follows: Meat consists of fresh beef, five days; bacon, three days; corned beef, one day; corned beef hash, one day.

Probably two or three days' supply of soft bread is taken when starting on a march; two days' supply of hard bread, and the remainder in flour; dried vegetables: beans, eight days; rice, two days; fresh vegetables: potatoes, six days; onions, two days; tomatoes, two days; and other components: jam, ten days; coffee, eight days; tea, two days; sugar, ten days; milk, ten days; vinegar, five days; pickles, five days; salt, ten days; and pepper, ten days. The milk is considered sufficient for the coffee. Where bread is noted on the bill of fare, hard bread, soft bread, or biscuits are to be served, according to circumstances.

This would seem to be substantial and palatable enough for the average military appetite, but the Commissary Department has caused the graduates of the cooking schools to be expert in preparing menus made from the materials listed.

The emergency ration is a new food by means of which the soldiers need never go hungry. It has been invented by the Commissary General, in connection with Capt. Jordan, and it consists of a little package not bigger than a deck of playing cards, or, when incased in tin, not larger than a half pint flask of whisky. It can be easily carried in one's breast pocket. This little package weighs only eight ounces, but it contains three full meals, and its nature is such that a man could live upon it for a long time if he had to. It is made of the component parts of milk and eggs, treated and mixed with chocolate. Each ration is in the form of three cakes of equal size. Each cake is wrapped in tin foil, and all three are inclosed in a hermetically sealed round-cornered tin box.

Is it strange that sailor and soldier proved their heroism and won victory in Cuba and in the Philippines, daring death itself? Yes, many of the brave died and others became hospital patients, but this time it was not because of starvation or unfit food.

The Diver in Winter

Sawing off a propeller blade under the ice of Toronto Bay

A DIVER'S task is not a pleasant one at best. He must put on a large rubber suit, a heavy brass helmet, shoes that weigh 16 pounds apiece, and a belt of lead weighing 80 pounds, all of which more than doubles his weight and makes it difficult for him to even stagger about when out of the water. Then when his suit is inflated, he is practically deprived of his hands as far as his own person is concerned. If his clothing does not set comfortably, if it produces any irritation such as pricking, tickling or itching, it is absolutely impossible for him to reach his body through the balloon-like suit to relieve the annoyance. We have read of a diver who was driven frantic by a fly which somehow became trapped in his helmet and persisted in buzzing around his ears and walking over his face. There was no way of driving off the tormenting fly, and finally the diver had to give the signal to be hauled up because he could not stand the torture any longer. A more helpless individual is hard to imagine. His hands are not his own. They belong to his work. He is dependent upon his attendants for his very breath. He can hear nothing, he can see nothing unless the water is very clear. Ordinarily it is difficult for him to see even his own hands at arm's length. The average diver has not yet adopted the telephone, and his only means of communication with the surface is the life-line with a limited code of signal jerks. Even the character and location of his work is not of his own choosing. He must be prepared to go down under the surface in the most difficult places under most trying conditions, and often in very gruesome situations.

Diving in winter when the water is covered with ice is even more unpleasant. He may be dressed warmly enough, but his hands which project out into the water will be numbed with the cold, unless they be covered with woolen-lined rubber gloves or mittens. In that case he is even more helpless because it is difficult for him to feel the work. If he is diving in sea water, the temperature about him may be even below freezing. He must depend upon the man at the surface to fend off floating slabs of ice that might carry off his precious air hose. It is remarkable that under such handicaps he can do any work at all.

Our cover illustration this week shows the city diver of Toronto, Canada, going down through the ice to work upon the propeller of a disabled tug. The tug "G. R. Geary," belonging to the water-works department of Toronto, was making its way through the ice to the intake end of the water supply tunnel when its propeller struck the ice and one of the blades was wrenched off. The fact was immediately detected by the thrashing, uneven action of the propeller. On account of the ice, it was impossible to put the tug in drydock and fit her with a new propeller. Hence it was decided to repair the damage by cutting off another blade. The propeller was a four-bladed one and by cutting off the twin of the blade that was wrenched loose by the ice, an evenly balanced two-bladed propeller would be left.

The propeller blade and the hacksaw that cut it off.

Diver Charles Margerison undertook the task of sawing through 22 inches of 3-inch thick metal under water. First the blade was notched so that he could readily find the kerf, should he have to take out the saw for any reason. Then he went at the tedious work in the darkness. The task was completed in two days, after eight hours of sawing, in which time two blades were broken and twelve others were dulled. One of our photographs shows the amputated blade and the hacksaw with which the work was done.

A rather remarkable piece of work was done by the same diver when he inspected 974 feet of the 6-foot intake pipe of the Toronto water works. Descending from a scow moored over the intake, he made his way into the pipe, using a second diver to lead in his life-line and heavy air-hose. He went 361 feet through the pipe, and in doing so, rose from a depth of 80 to 36 feet. Owing to the varying hydrostatic pressure, this was an exceedingly difficult piece of work. It took two hours to make this inspection. Then the tunnel was entered from another point, and the diver worked back toward the intake for a distance of 613 feet. In place of the ordinary diver's hand pump, a compressor and an air storage tank were employed.

How to Mount Diatoms*

Care Used in Selecting Materials and in Making the Delicate Settings

By E. Leonard

BEFORE proceeding with instructions as to the actual mounting, it would be well that I should describe to you the apparatus and materials I use. The order that I shall mention them in is exactly the order in which they would be made use of in mounting:

1. A "searching-over" slip, 3 by 1, ruled with a diamond very lightly in vertical lines 1/25 inch to 1/50 inch apart. It is best when preparing these to make half a dozen, not only to allow for breakages, but also for the drying-off at one time of three or four slips containing the "dips" to be searched over.

2. A piece of glass tubing 3/32 inch internal diameter and about 6 inches long. The tube out of the old style of baby's feeding-bottle is just the right size. This tube is narrow enough to allow a cotton-and-wire pipe-cleaner to thoroughly cleanse it of any stray discoid forms that might be hanging around from previous dippings. I always make it a rule, after every dip, to clean the inside of the tube with the pipe-cleaner and wipe the outside with a clean handkerchief. Thus no diatoms from one locality can be confounded with those from another. Of course, this also prevents the wonderful discovery of a marine form in a fresh-water lake 200 miles inland! A pipette which narrows at the mouth is apt to cause trouble on this account, as it cannot be cleaned freely like a straight tube.

3. An ordinary slip with a small circle thereon about 1/8 inch in diameter, to store diatoms in as picked off the "searching-over" slip. For convenience in working, both slips should be of exactly the same thickness.

4. A turntable.

5. Some carmine or other color water-color in *blocks*, *not* moist color in *pans*. I use Windsor and Newton's best carmine, at 7d. a half-cake. This will last a lifetime. Moist color seems to have some spirit in its composition which does not agree with my fixatif. To bring into use, put a little water on a bit of glass or china, and grind end of cake round and round until a sufficiency for ringing is made up.

6. A sable brush as fine as possible (size "00," if one can get it) for making guide-rings.

7. A "fixatif" of two densities—one for fine diatoms, and one for heavy forms. The fixatif I use is made up as follows: 100 parts collodion (B.P. formula), 500 parts absolute alcohol, 500 parts methyl-ether, 25 parts pure oil of cloves. This density can be used for most forms; but for very fine diatoms I use a mixture containing 750 parts each alcohol and ether, other proportions (100 collodion and 25 oil of cloves) remaining the same. Mix the collodion, alcohol, and ether, and then add oil of cloves. Keep bottles well corked.

8. Two or three hairs mounted in penholders—fine, medium and heavy. Any fine, flexible hair is suitable. I use cat's whisker-tips; they are excellent. Sharpen penholder to a point, pierce as fine a hole as possible, then with forceps drop in hair; have a drop of Hollis's glue on point of a needle, and apply to base of hair; glue will run in, and when dry the hair is fast. I have only 1/4 inch to 3/8 inch of hair in use. I do not believe in a long hair; it affords less control.

9. Some sort of support for cover-glass where specimen has thickness or processes. Broken cover-glass will do; but I use tiny discs of aluminium about 3/1000 inch in thickness. (See description in the *Quekett Microscopical Journal* for April, 1892.) I do not know that these can be obtained ready-made.

10. A spirit-lamp and water-bath.

11. Some watch-glasses to use as covers while fixatif is drying.

12. Xylol.

13. Styrax and xylol.

14. Hollis's glue or brown cement for ringing.

The above sounds a somewhat formidable list; but most mounters will find they have the bulk of the materials by them already, and none of the articles listed are expensive.

As to the instrument under which I mount, it is a Swift-Stevenson's special mounting binocular. This greatly simplifies one's work, but is by no means a necessity. Firth, of Belfast, whose beautiful work (groups sometimes of 200 forms) is well known to many readers, uses an ordinary inclined model with a small stage. It is, however, a very good thing to make some wood blocks, sloping upward, so as to bring the wrist to about the level of the stage.

If one has a flat stage, then I strongly recommend a tray such as I will describe. It is about 3½ inches long by 2½ inches wide, with narrow strips of glass cemented on three sides. You thus have a tray on which two 3 by 1 slips will be side by side, and move continuously in the same plane. At the bottom of the tray can be placed

*A paper read before the Liverpool Microscopical Society and printed in the *English Mechanic and World of Science*.

the "searching-over" slip, and above it the storing-slip Thus one has always one's store-cell ready to hand, and the risk of losing a specimen in transferring from one slide to another is practically eliminated.

Now that I have described all the materials necessary, I will proceed to the actual mounting. Take a bottle of clean diatoms. Gently shake the bottle, and insert end of tube. By placing one's finger over the other end, a certain amount of water and diatoms can be withdrawn and transferred to the "searching-over" slip. Start at one end of the latter, and draw tube along center, and, if slide be *clean*, one should have an evenly-distributed quantity of diatoms, sand, etc., the whole length of the slide—no thick patches, waves, etc. Then put slide on the "hot-plate"—but the latter, to commence with, must be *quite cold*—and gently warm up till slide is dry. If diatoms were really clean and free from acid, then there ought not to be any case of the diatoms adhering to the "searching-over" slip. Of course, with very fine forms like Pleurosigma, etc., there is nearly always considerable difficulty in this respect. Generally it is easiest to pick such out wet, balancing diatom on extreme end of hair, and finding, if possible, a broken spicule or something on which to deposit diatom while drying, and when dry transferring to store-ring. For picking out, I use a medium hair. If a big form is stubborn, I give it a *gentle* push with heavy hair, and usually that is sufficient to move it. If it will not, have a small bottle of distilled water handy, and keep on jabbing point of hair below surface until a small globule adheres to hair, then transfer globule to *close by* the diatom to be moved, and with point of hair draw water toward diatom. Once loosened, keep the latter moving until dry again, when generally you will find it ready to transfer to store-cell. If still refractory, leave if a common form; go at it again if scarce.

If there is dirt on the diatom, remove latter to a cleaned slip (not the store-cell, but one with no ring on), pick up a globule of distilled water on finest hair, envelop the diatom with same, and then shove the diatom about, beat it, prod it, prick it, tickle it, or do anything you like (except break it), and usually you can get the dirt away—of course, under water all the time, the water acting as a cushion between the diatom and one's often impotent fury! Beware of prodding *hard* a diatom that sticks when dry: he either "busts" or disappears into space like a stone from a catapult.

Now, having caught your hare, proceed to cook it, first preparing your utensils.

Except for very delicately marked specimens, I always mount on the slip, using thin cover-glasses. Modern objectives have plenty of working distance. Take a 3 by 1 slip, clean thoroughly, then put on turntable, and in center of slip make a neat and small guide-ring: 1/16 inch internal diameter is quite big enough for three or four ordinary specimens. To those who are not in the habit of making these small guide-rings I would recommend a couple of hours' practice making such rings. A neat ring looks nice under the instrument; but an untidy one will leave an unpleasant recollection, no matter how beautiful the specimen may be. These remarks not only apply to diatoms, but to all objects which need a guide-ring. By the way, these guide-rings serve a double purpose. No doubt everyone knows the great difficulty of trying to locate a very minute object under 1/4 inch or higher power. The guide-ring fills the field of a sixth, and when once you have found the ring, it is easy enough to find the diatom if the latter is mounted in center of guide-ring, as it should be. Another point gained is that one can focus the paint, and know that one's object is also in focus, or very nearly so. The latter, however, only applies to objects mounted on slip, and not to those mounted on cover-glass.

I omitted to say that I keep the collodion fixatif in tubes about 7/8 inch by 3 inches, and they must have perfectly-fitting corks, or it will be found one day that the ether and alcohol have evaporated, leaving a thick jelly which is of no use at all. Into each cork I stick about 2 inches of fine quill. Near the cork, a notch must be cut, and the lower end of quill should be cut square, not slanting. The quill, of course, goes right down into the fixatif, and when cork is drawn out, about 3/8 inch of quill is full of fixatif.

Now to proceed. After making a guide-ring, hold slip over lamp until it is quite hot, and all moisture driven off: moisture does not agree with collodion, and if present causes clouding, which, however, can be driven off by reheating. Still, prevention is better than cure. While the slip is still hot—hot as your fingers will stand—draw cork out of fixatif-bottle, tilt slip to an angle of 45 degrees, and apply tip of quill to surface about 1/8 inch to 1/4 inch above the guide-ring. The fixatif will immediately leave quill and spread itself nicely around. It does not matter if it goes beyond area coverable by cover-glass, as it can be cleaned off afterward by breathing on it and rubbing with a soft rag. This latter to be done, of course, only when slide is hardened off.

At this stage of the proceedings I put on my cover-glass supports, placing them triangularly about 1/8 inch from edge of guide-ring. They can be easily pushed into position with a fine needle. See they are well buried in the fixatif, or later on, when heating, they may slip and spoil appearance of slide. Next put slip under the microscope, and if slightest bit of dust inside guide-ring, push or draw it out with stout hair, and everything is ready to put your object into place. Pick up the diatom (right side up) by the hair that has been used for removing dust from guide-ring (it will be a bit sticky, and diatom will adhere), and then place diatom in center of ring, or, if you are mounting more than a single specimen, as near to final position as possible. Do not be alarmed if it buries itself in the fixatif, or looks as if it had taken down air with it, but see that it lies nice and flat. Fixatif, owing to the oil of cloves, remains tacky from thirty to fifty minutes, so that one can mount forty to fifty specimens (or more) if one wishes. When you have in position all the diatoms you are mounting on that particular slip, put the latter on hot-plate, pop a watch-glass over it, and leave for twenty to thirty minutes. This should drive off alcohol, ether, and oil of cloves, leaving diatoms firmly fixed in a very thin film of collodion, as also the cover-glass supports. For fine diatoms, use lighter density of fixatif. After this drying-off, push diatom gently with stout hair, and if diatom does not move, you may consider it ready for next step. Put slip on microscope stage, and with a pipette (fine-pointed) drop the smallest quantity possible of pure xylol on the diatoms (mind you do not smash specimens in doing this). If whole diatom clears at once, well and good, and you can proceed to drop some styrax on it. I use only 3/8 inch cover-glasses (No. 1's), and find one drop of styrax plenty to fill up the area of 3/8 inch. Big circles probably need more. Then put slide, as it is, with styrax, back on the hot-plate, cover with watch-glass, and leave for another twenty or thirty minutes; then take off, and put on cover-glass, replace on stove, and the cover-glass will quickly make contact and settle into place. Finally, completed slide ought to have twenty-four hours' baking on a hot-plate at a temperature of 130 degrees to 140 degrees, when by that time it should be impervious to oil of cedarwood or anything else. But the slide will take no harm from a ringing of Hollis's glue or Brown's cement. By the way, solvent for Hollis's glue is wood-naphtha.

To revert. If xylol does not quite clear the specimens, but leaves a little air still showing as a bubble, sit and watch it until all the air disappears, and then put on styrax, and proceed as before mentioned. If bubble is very stubborn and not inclined to disappear, have some xylol in a wide-mouthed stoppered bottle, and put slide in and leave for a time (hours or days), when it is almost certain to clear, and can be finished off. By the way, it is as well to put some sort of a mark on the top surface of slide, as when slip is withdrawn from xylol bottle it is difficult to tell which side of it the diatom is on. I scratch a number on corner of slip with a diamond, and that number can also be used as an index to jot down locality from which the diatom is taken.

Possibly, after dropping on styrax, air-bubble will reappear. I do not understand why, but it does so, though such a bubble nearly always disappears during the twenty-four hours' baking. Should you find it necessary to remove any dirt, or specimen, after hardening the fixatif (but before styrax is put on), the fixatif can easily be softened by dropping on a little pure alcohol (not ether, as the action of the latter is violent).

For baking slides after completion, I use an ordinary copper breakfast hot-plate, substituting a small Bunsen burner for the spirit-lamp, keeping the temperature at about 130 degrees to 140 degrees for twenty-four hours. At the end of that period you will find the styrax that has exuded from underneath the cover-glass very stiff and tacky, even while hot, and quite hard when cold. Superfluous styrax should be removed with a rag dipped in xylol or methylated spirit.

As a final word of warning, styrax is very variable in its hardening properties, and while generally twenty-four hours' baking is sufficient to harden, some styrax will need thirty-six hours. But a little experimenting in this direction will very soon prove how long a baking must be given.

History of the Views of Nervous Activity

The Functional Difference Between Sensory and Motor Nerves

By D. Fraser Harris, M.D., D.Sc., B.Sc. (London), F.R.S.E.
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It is always instructive to trace the growth of an idea, to be able to watch the notion of something, even of so elusive a thing as the nerve-impulse, grow gradually in clearness and in definiteness as the centuries roll on.

The term "nerve-impulse" is, of course, wholly modern. It would not be profitable to go farther back than the time when the Greek philosophers imagined that the nerves were hollow and conveyed "spirits" through the pores (poroi) of their substance.

The Alexandrine School of Greek Anatomy, founded as far back as 300 B. C. by Ptolemy I., recognized the functional difference between sensory and motor nerves. The two best known teachers in it—Herophilus and Erasistratus—devoted much attention to the nervous system; they dissected the nerves to their origins in the brain and spinal cord, they displayed the veins of the brain and investigated its cavities or ventricles, believing that in the Fourth of these, in the Medulla Oblongata, the soul was situated. The meeting place of the venous sinuses of the coverings of the brain is still known as the Torcular Herophili. The physiology taught by Claudius Galen of Rome (131–200 A. D.) was an outgrowth of the Alexandrian. Galen had the clearest conception of the nerve-trunks as merely conductors of something—he called it spirits—to or from the brain and spinal cord. The doctrine of spirits in general he elaborates so as to recognize three kinds of spirits—natural, vital and animal. We can hardly understand the nerve physiology of the Middle Ages without some notion of these three kinds of spirit. Briefly it was this: the food in the intestine is absorbed into the portal vein and goes to the liver, where it is worked up into blood which is endowed with natural spirits, or, in modern language, with the powers of nourishing the tissues of the body. The crude blood was then supposed to pass from the liver to the right side of the heart whence most of it percolated through the septum to the left ventricle. This process to some extent refined the blood. In the left auricle in diastole, air was sucked into the heart; which brought about two results, the cooling of the innate heat of the heart and the generating of vital spirits. The vital spirits were carried by the blood in the arteries to all tissues and organs to enable them to perform vital functions. The blood with its vital spirits that went to the brain was supposed to undergo a sort of distillation or refining for the last time, with the result that the animal spirits were separated from it and carried to the body by the nerve-trunks. The animal spirits in motor nerves made muscular movements possible, those in sensory nerves were productive of sensations.

We still speak of animal spirits, of "a man of spirit," and so forth; and the expression "the vapors of alcohol" or "fumes of drugs ascending to the brain" are based on the analogous ascent of vital spirits from the heart to the brain. As recently as the time of Queen Anne (1708) the *Daily Courant* advertised a perfume as efficacious because "it increases all the spirits, natural, vital and animal." This is exactly in the Galenical order.

The point of interest for us in all this about spirits is that thus early we have glimmerings of the notion of innervation, the agent of which is spirits; for the animal spirits of Galen are the nerve-impulses of to-day. It will be noticed, however, that there is in this ancient doctrine of spirits some sort of latent distinction between powers of absorbing nourishment, of expressing vitality, and of conferring movements. The modern advance on this is that not even the absorption of nourishment is outside of innervation. The growth of the ideas of innervation centered, as might have been expected, round the power to arouse movements in muscles, in fact, around motor innervation only.

The problem which so agitated the physiologists of the eighteenth century had not arisen in Galen's time, namely, whether muscles contracted of themselves, for instance, after all their nerves were cut (doctrine of Inherent Irritability), or whether all their irritability was conferred on them through their nerves, that is, from outside, the so-called doctrine of the Neurologists.

For the sake of clearness it may be well to say at once

that muscles have irritability of their own, after all their nerves are cut, but that unless nerve-impulses (tonic) are constantly pouring down upon them, and unless stimuli to action are frequently being received by them, they will waste away because there is nothing to call forth the power of contraction which they do possess.

As regards views on the working of the nerves, we find nothing of any consequence from the death of Galen (200 A. D.) to the time of Vesalius (1543), for the interval of more than a thousand years was occupied by the Dark Ages when there was hardly any investigation of living nature, and very little curiosity about the mysteries of life.

Vesalius wrote of muscle that it "also receives branches of arteries, veins and nerves, and by reason of the presence of the nerve is never destitute of animal spirits so long as the animal is sound and well. . . . Nor do I with Plato and Aristotle (who do not at all understand the nature of muscle) attribute to the flesh so slight a duty as to serve the purpose of lessening the effects of heat in summer and of cold in winter. On the contrary, I am persuaded that the flesh of muscles, which is different from everything else in the whole body, is the chief agent by the aid of which (the nerves, the messengers of the animal spirits, not being wanting) the muscle becomes thicker, shortens and gathers itself together." Thus writes Vesalius, who does not attempt any explanation; he does not know what spirits are, or how they affect the muscle, or why it *shortens* when they do affect it; he only knows that something in nerves does influence muscle.

G. A. Borelli of the University of Pisa (1608–1679), the mathematician and author of the *De motu animalium*, endeavored to be more exact in his conception of *how* this activity of muscle came about under the influence of nerve-impulses.

Borelli at the outset fell into the error that a muscle increases in volume when it goes into activity. He then attempted to get some idea of what these animal spirits were which apparently could inflate muscle, and he thought they must resemble air. But when he cut an active muscle across under water no bubbles of air or gas come out of it; therefore, he concluded, the spirits were not gaseous. Nevertheless, something real descends the nerves to influence the muscles, and so Borelli finally called this something the "succus nerveus," or nerve-juice. The analogy he had in his mind was that of an incompressible fluid in a flexible tube which can conduct rapidly from one end to the other of it the disturbance produced by a tap or concussion.

The position of the acute and critical Dane, Stenson or Steno (1638–1686), was wholly agnostic. He wrote, "As the substance of this fluid (nerve-juice) is unknown to us, so is its movement undetermined." Although Steno left the problem of the nature of nerve-impulses unsolved, yet he clearly distinguished between neural activity and muscular irritability.

The Englishman Thomas Willis (1621–1675) reverted to Borelli's position, believing that spirits leaped from the nerves into the muscle-fibers and so dilated them.

Francis Glisson (1579–1677), who formally introduced the conception of irritability into physiology in 1662, contributed something to this subject by showing experimentally that a muscle did *not* alter in volume when it went into a state of activity or contraction. By muscular "contraction," therefore, we do not mean shrinking in volume; the volume and the density of a muscle remain constant whether in rest or in action.

The great investigator Stephen Hales (1677–1761) made an interesting remark about the nerve-impulse, asking "whether it is confined in channels within the nerves or acts along their surfaces like electrical powers." This is probably the earliest suggestion that the nerve-impulse and electricity have anything in common.

By many subsequent writers, nerve-impulses were considered identical with electricity. The discoveries of Galvani seemed to make such a thing probable. Those experiments of his known as "contractions without metals" seemed to prove that muscles would contract when stimulated by electricity of purely animal origin. What, then, more probable than that nerve-impulses and animal electricity were the same thing? Popular writers forthwith assumed this to be the case, although it was not warranted by any of Galvani's experiments. Galvani's experiments really proved that the feeble differences of electrical potential developed by injuring nerves or, for instance, by the activity of the heart, were sufficient to make a muscle (of the frog) contract. Galvani was right that there was such a thing as animal electricity, but he was wrong in attributing muscular contraction to it in such cases as those where there were contacts of dissimilar metals. Volta was wrong in denying the existence of electricity of animal origin, but right in claiming that some electricity was of metallic origin and was the true stimulus in several cases in which Galvani thought it to be of animal origin.

It is only comparatively recently that the non-electrical nature of nerve-impulses has been established.

Albrecht Haller (1708–1777) brought the subject into the domain of modern thought by distinguishing three things: the inherent irritability of muscle (the *vis insita*), the nerve-impulse (*vis nervosa*), and the stimulus to the muscle which might or might not be the *vis nervosa*. Writing of the *vis nervosa* he said: "It comes from without, and is carried to the muscles from the brain by the nerves; it is the power by which the muscles are called into action." The *vis nervosa*, taking the place of the *succus nerveus*, remained in nerve physiology until about the middle of the nineteenth century.

Robert Whytt, of the University of Edinburgh (1714–1766), though he furthered the study of reflex action, did not understand nerve-impulses as clearly as did Haller with whom he had a long controversy. Whytt denied to muscle inherent irritability, and thought it was conferred on them by the nerves; he held that the stimulus could convey energy—a view now rightly regarded as a neurological heresy. The controversy lingered on until John Reid (1809–1849) demonstrated that muscles severed from their nerves could, under suitable conditions, retain their contractility for months.

The suitable cond t ons were: (*a*) blood-supply for the muscles and (*b*) their being constantly "exercised by Galvanism." Reid in this way prevented the muscles showing atrophy from disuse. He kept them in good condition by artificial, electrical instead of by normal, neural stimulation; but the irritability must have been inherent in them in order that the stimuli should act on them at all. The artificial stimuli could not have conferred irritability on the muscles, neither, then, did the normal, neural stimuli. The reception of nerve-impulses (neural stimuli) was only the occasion of the muscles exhibiting the contractility which they possessed independently.

This incomplete historical survey affords us one more instance of what is so interesting in the progress of science—the tendency toward concreteness in conception. We begin in Antiquity with "spirits" in the nerves; the science of the Renaissance converts these into *succus nerveus*, an incompressible fluid such as was being investigated by the physicists of that time; the eighteenth century gives us the *vis nervosa*, which later is identified with the electric current then being studied both in Italy and in England. In the nineteenth century we have nerve-impulses not only measured as to the velocity of their traveling, but actually rendered visible through their concomitant electrical effects. Nerve-impulses are not electricity, but they produce it and can be manifested by it. Thus each generation must think and express itself in the language of its own time.—*Science Progress.*

Niello or Nielled Silver

NIELLO was known hundreds of years ago, and was apparently lost sight of, but came in use again lately. The method of manufacture is: An article of sterling silver or a silver alloy is deeply engraved in the usual manner. The cuts of the engraved design are then filled with silver, copper and lead *sulphides*. This mixture of sulphides is black, and adheres tenaciously to the silver, and instead of the deep engraving there appear black lines. The sulphide is fused into the silver, and is the most permanent black known, on account of its thickness. Niello is now rarely found in the trade. The best qualities come from Russia, and command a high price. The manufacture of niello dates back to the eleventh century; and Percy, the celebrated metallurgist, states an account of it was written by Theophilus, or Rugerus, a monk of that period. The mixture used in Russia and Persia for enameling silver jewelry is stated to be:

Silver	0 oz.	4 drm.
Copper	2 "	4 "
Lead	3 "	4 "
Sulphur	12 "	0 "
Ammonium chloride	2 "	4 "

Make a paste of the sulphur with water, and put it in a crucible. Melt the metals, and pour them into the crucible which contains the paste. Cover this, so that the sulphur may not inflame, and then calcine till all excess sulphur is volatilized. Finely pulverize the mass, and make a paste with a solution of ammonium chloride, and rub this paste into the parts to be enameled. Clean the article, and heat it in a furnace until the paste melts and adheres to the metal. Moisten the article with a solution of ammonium chloride, and heat in a muffle to redness. The article, when cold, can be rubbed and polished without detaching or altering the enamel, which retains its fine black color.

The proportions of the metals used at various times were:

Authority.	Silver, Per Cent.	Copper, Per Cent.	Lead, Per Cent.
Pliny	75.00	25.00	.....
Theophilus	66.67	22.22	11.11
Biringuccio	16.67	33.33	50.00
Bénvenuto Cellini	16.67	33.33	50.00
Blaise de Vigenére	16.67	33.33	50.00
Perez de Vargas	16.67	33.33	50.00
Georgi (in Russia)	7.69	38.46	53.85
Répertoire of Patent Inventions, 1827	5.88	35.30	58.82

The sulphur and ammonium chloride are used as previously described. It is noticeable that the oldest niello mixture contains the most silver and no lead, while lead is the principal ingredient in the latest. The foregoing method of making nielled silver is costly, since each article must be engraved. It might be cheapened by engraving in relief a steel plate and compressing it against a silver plate between two hard bodies. A great many copies may be obtained from the same matrix.—*Brass World.*

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